Office of Science
Executive Budget Summary

The Office of Science (SC) requests $3,151,065,000 for Fiscal Year (FY) 2001in the “Science” appropriation, an increase of $363,438,000 over FY 2000, to invest in thousands of individual research projects at hundreds of research facilities across the U.S., primarily at our national laboratories and research universities. In addition, the FY 2001 request will support: continuing construction of the Spallation Neutron Source; increasing investments in nano-scale science to make significant contributions to the interagency initiative in nano-technology; implementing advanced computational modeling and simulation for DOE’s broad scientific challenges; investigating the workings of the microbial cell for DOE applications; improving the utilization of our major scientific user facilities; and updating the skills of our technical workforce. Within the “Energy Supply” appropriation an increase of $702,000 is requested for the Technical Information Management program.

A History of Success:

The National Academy of Sciences has noted that much of U.S. economic growth, quality of life, and security derive from the national investment and leadership in science and technology. In FY 2000, the Department of Energy (DOE) is the third-largest government sponsor of basic research in the U.S., principally through the programs managed by SC. In service to DOE’s applied missions in energy resources, national security, and environmental quality, SC programs lead the nation in many areas of the physical and computational sciences and contribute significantly to major advances in biological and environmental research. These programs have extended the frontiers of science and contribute to our economy through achievements such as:

- Supporting the fundamental research of 70 Nobel Laureates, from Enrico Fermi and E.O. Lawrence to Richard Smalley and Paul Boyer;
- Contributing to the development of the current generation of high-energy and high-power-output lithium and lithium-ion batteries through research in nonaqueous electrolytes;
- Enabling treatment of disease and addiction by building on brain-imaging studies based on SC work in Positron Emission Tomography;
- Developing computational ability exceeding one teraflop of sustained performance for DOE research applications;
- Advancing miniaturization through research into nanowires and phenomena such as conductance quantization;
- Advancing the physics of plasmas, a key element in the manufacture of materials coatings, semi-conductors, lighting systems, and waste disposal systems; and
- Discovering quarks, from the original three light ones - up, down and strange - to the heavy ones - charm, beauty, and top. All of the quarks were discovered at DOE laboratories between 1960 and 1995.

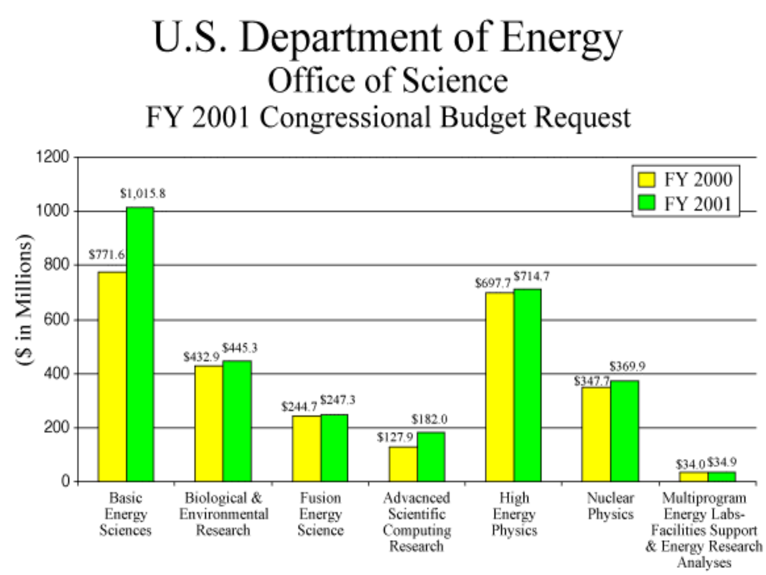

Figure 1

A New Plan for DOE Science:

The 20th century has brought many scientific advances that have resulted in dramatic changes in our standard of living. New opportunities are opening every day as we learn to control matter at the atomic level, develop cleaner new energy sources, simulate that which we cannot easily test in the laboratory, and look deeply into the cosmos to the very origins of matter and energy. At the same time, federal science programs are being called upon to deliver more for less. Managers and scientists must scrutinize their investments and establish priorities more carefully than ever before.

The SC Strategic Plan and Science Portfolio, published in June 1999 and available on the Web at www.sc.doe.gov, are part of a long range planning process to define the goals, objectives, strategies and portfolio of research that will enable DOE to succeed in it's technology driven missions. Bold new questions and intriguing scientific challenges designed to build the scientific foundations for a strong and prosperous nation in the 21st century are contained within the pages of the SC Strategic Plan. The goals of the Strategic Plan are outlined in Figure 2.

Figure 2

The Science Portfolio provides the link between the goals and strategies of the Plan and the research activities within the SC programs. The Portfolio identifies the motivations, activities, accomplishments, and near-term resources for SC's research programs.

Development of the Strategic Plan and Portfolio identified new opportunities in high impact areas of research. Roadmapping efforts are under development to explore the potential of complex systems, carbon sequestration, computational modeling and simulation, and scientific facilities as applied to SC research interests. The roadmaps will identify the steps that are needed to achieve the desired DOE goals.

Implementing the Plan - Priorities:

The FY 2001 budget request, depicted in Figure 1 and Table 1, has a program structure that meets our mission, consistent with departmental goals and strategies. The major SC programs are High Energy and Nuclear Physics, Basic Energy Sciences, Biological and Environmental Research, Advanced Scientific Computing Research, and Fusion Energy Sciences.

The five goals contained in the Strategic Plan provide a framework for current programs and a platform for future efforts. FY 2001 initiatives and priorities are detailed below.

Nanoscale Discovery - The principal missions of the DOE in Energy, Defense and the Environment will benefit greatly from future developments in nanoscale science, engineering and technology. The SC research program has a strong focus on nanoscale discovery, the development of fundamental scientific understanding, and the conversion of these into useful technological solutions.

A key challenge in nanoscience is to understand how deliberate tailoring of materials on the nanoscale can lead to novel properties and new functionalities. Examples include: the addition of aluminum oxide nanoparticles that convert aluminum metal into a material with wear resistance equal to that of the best bearing steel; novel chemical properties of nanocrystals that show promise as photocatalysts to speed the breakdown of toxic wastes; and, meso-porous structures integrated with micromachined components that are used to produce high-sensitivity and highly selective chip-based detectors of chemical warfare agents. These and other nanostructures are already recognized as likely components of 21st century optical communications, printing, computing, chemical sensing, and energy conversion technologies.

The DOE is well prepared to make major contributions to developing nanoscale scientific understanding and ultimately nanotechnologies through its research programs and its materials characterization, synthesis, in-situ diagnostic, and computing capabilities. The DOE and its national laboratories maintain a large array of major scientific user facilities that are ideally suited to nanoscience discovery and to developing a fundamental understanding of nanoscale processes.

FY 2001 funding is being requested as part of the proposed multiagency National Nanotechnology effort. New efforts are proposed to attain a fundamental scientific understanding of nanoscale phenomena; to achieve the ability to design and synthesize materials at the atomic level to produce materials with desired properties and functions; to attain a fundamental understanding of the processes by which living organisms create materials and functional complexes to serve as a guide and a benchmark by which to measure our progress in synthetic design and synthesis; and to develop experimental characterization tools and theory/modeling/simulation tools necessary to drive the nanoscale revolution.

The synergy of these DOE assets, in partnership with universities and industry, will provide the best opportunity for nanoscience discoveries to be converted rapidly into technological advances that will meet a variety of national needs and enable the U.S. to reap the benefits of an emerging technological revolution.

Non-Defense Scientific Supercomputing— Computational modeling and simulation is one of the most significant developments in the practice of scientific research in the 20th century. Scientific and engineering simulation has dramatically advanced our understanding of nature and has been used to gain insights into the behavior of such complex natural and engineered systems as the weather, materials properties, turbulence and fluid flow, and high-density plasmas.

Dramatic advances in computer technologies in the past decade have set the stage for major advancements in computational modeling and simulation capability. Within the next five years, high-performance computing systems capability will increase by a factor of 1000 (to terascale computing). These computing systems will enable scientists to predict the behavior of a broad range of complex natural and engineered systems at a level of accuracy and detail never before achieved. This will have an enormous impact on broad classes of scientific research and will ultimately address DOE's most demanding, mission-driven challenges.

DOE has a long history of accomplishment in scientific computing. As a result, the Department has served as the proving ground for new computer technologies—subjecting these technologies to the demands that only its most computationally intensive simulations could provide. In 1974, the Department established the first civilian supercomputer center for a national scientific community, the National Magnetic Fusion Energy Computing Center, which became a model for centers established a decade later by NSF and other agencies.

DOE's achievements in software for scientific computing are equally impressive. DOE led the transition from the vector supercomputers of the 1970s and 1980s to the massively parallel supercomputers of today, providing much of the basic software required to use the massively parallel supercomputers. Many of the scientific simulation software packages for massively parallel supercomputers were developed by DOE, a fact recognized by periodic awards from the supercomputing community.

To realize the advances promised by terascale computing, SC will focus on: the development of: a new generation of computational modeling and simulation software that takes full advantage of terascale computers; and the terascale systems infrastructure and software needed to make terascale computers usable for advanced scientific simulation.

The proposed investments support the recommendations outlined in the report by the President's Information Technology Advisory Committee (PITAC) and take advantage of the capabilities being developed in the Accelerated Strategic Computing Initiative (ASCI) in the Office of Defense Programs for DOE's "Stockpile Stewardship Program."

Simulation of complex systems requires integration of a broad range of physical, chemical and biological processes, knowledge of which can cut across research programs in the Office of Science. In addition, terascale computers pose problems far more complex than those encountered with vector supercomputers, necessitating close collaboration between disciplinary computational scientists, computer scientists, and applied mathematicians. The formation of integrated, multidisciplinary teams is the key to success, an approach that DOE has successfully exploited in many past projects, ranging from the development of new accelerators to the establishment of the fundamental basis for understanding climate change.

Spallation Neutron Source (SNS) - As the needs of our high technology society have changed, so have the ways in which we develop new materials to meet these needs. It has become increasingly important to create new materials that perform under severe conditions and yet are stronger, lighter and cheaper. Major research facilities are used to understand and "engineer" materials at the atomic level so that they have improved macroscopic properties and perform better in new applications. The SNS is a next-generation facility for just this kind of research.

The SNS project will provide a short-pulse spallation neutron source for neutron scattering and related research in broad areas of the physical, chemical, materials, biological and medical sciences. When completed in 2006, the SNS will be more than ten times more powerful than the most powerful neutron source now in existence. The total project cost for the SNS is $1,440,000,000.

Neutron scattering will play a role in all forms of materials and design, including the development of smaller and faster electronic devices; lightweight alloys, plastics and polymers for transportation and other applications; magnetic materials for more effective motors and for improved magnetic storage capacity; and new drugs for medical care.

Researchers from academia, the national laboratories and industry will use the SNS to conduct research. Both basic and applied research will be conducted as will technology development in the fields of condensed matter physics, materials sciences, magnetic materials, polymers and complex fluids, chemistry, biology, and engineering. It is anticipated that 1,000-2,000 scientists and engineers will utilize the SNS each year and that it will meet the nation's need for neutron research well into the 21st century.

The SNS is a partnership between five DOE laboratories [Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL), Lawrence Berkeley National Laboratory (LBNL), Los Alamos National Laboratory (LANL), Oak

Ridge National Laboratory (ORNL)] that takes advantage of the specialized technical capabilities of each laboratory.

The project is centrally managed from the SNS Project Office at ORNL under the leadership of an experienced Project Executive Director, who has primary authority over the project staff at all five laboratories.

Scientific Facilities Utilization - The FY 2001 budget request strongly supports Scientific Facilities Utilization in the following programs: Basic Energy Sciences, High Energy Physics, Nuclear Physics, Fusion Energy Sciences, Biological and Environmental Research, and Advanced Scientific Computing Research.

Each year, over 15,000 university, industry, and government-sponsored scientists conduct cutting edge experiments at these particle accelerators, high-flux neutron sources, synchrotron radiation light sources, and other specialized facilities. The user community continues to be pleased with the service provided to them by the SC scientific facilities, as evidenced by their many letters of support and by the positive results of surveys conducted at the facilities.

In FY 2001, operating budgets are increasing at the synchrotron radiation light sources and the neutron scattering facilities to provide increased operating time and support for users and to fabricate instruments and beamlines to serve the large and growing user community at these facilities.

Large Hadron Collider (LHC) - The foremost high energy physics research facility of the next decade will be the LHC at CERN, the European Laboratory for Particle Physics. The primary physics goals of the LHC will impact our understanding of the origin of mass through studies of the elusive "Higgs" particle, exploration of the structure and interactions of quarks, and unanticipated phenomena. The High Energy Physics Advisory Panel (HEPAP) strongly endorsed participation in the LHC to provide U.S. access to the high energy frontier in order to maintain the U.S. as a world leader in this fundamental area of science.

DOE and the National Science Foundation (NSF) have entered into an agreement with CERN about contributions to the LHC accelerator and detectors as part of U.S. participation in the LHC program. This agreement, signed in 1997, provides access for U.S. scientists to the next decade's premier high energy physics facility. Under the agreement, the DOE will contribute $450 million ($250 million for the detectors and $200 million for the accelerator) to the LHC effort over the period FY 1996 through FY 2004. The total cost of the LHC is estimated at about $6 billion.

SC has conducted cost and schedule reviews of the U.S. funded components of the LHC project. All of the reviews concluded that the costs are properly estimated and the schedule is feasible.

The agreement with CERN also provides for U.S. involvement in the management of the project and participation in key management committees. This will enable the U.S. to monitor the progress of the project and to ensure full access for U.S. scientists to the research opportunities of the facility.

Fermilab is the lead laboratory for the accelerator portion of the U.S. LHC program, which it will execute in cooperation with BNL and LBNL. BNL is the host laboratory for the ATLAS detector, which also involves ANL, LBNL, and 28 university groups.

Fermilab is the host laboratory for the Compact Muon Solenoid (CMS) detector portion of the project, including BNL, LANL, and 33 university groups. Cost and schedule baselines have been reviewed and validated for each of the three portions of the project, and management systems are in place to monitor progress against baselines.

Life Sciences – Beginning in FY 2001, the Office of Science will support two key areas in the life sciences –– the Microbial Cell Project and Biomedical Engineering.

The goal of the Microbial Cell Project is to develop a comprehensive understanding of the complete workings of a microbial cell. Examples include: DNA sequence; the identification of all of the microbe's genes; the production of all of the proteins whose assembly instructions are contained in the genes; and the complex interaction of the genes and proteins in a cell that give the microbe its life and its unique characteristics and behaviors.

The key scientific challenges are far greater than simply understanding how individual genes and proteins work. We need to understand how genes and proteins are regulated in a coordinated manner and how they are integrated into a functional, interactive cell. The Microbial Cell Project will challenge scientists to go beyond the leveraging of tools and technologies for high throughput DNA sequencing. This will require high throughput approaches for determining the structure and function of proteins, computational biology and bioinformatics resources; the development and use of sophisticated imaging and analytical sensing technologies; and novel approaches to modeling and analyzing complex systems.

This information will address DOE needs in energy use and production, bioremediation, and carbon sequestration, and will provide exciting, new, and previously unavailable information to the entire biological community.

The Biomedical Engineering Program capitalizes on DOE's unique resources and expertise in the biological, physical, chemical and engineering sciences to develop new research opportunities for technological advancement against problems dealing with human health. This activity will: advance fundamental concepts; create knowledge from the molecular to the organ systems level; and develop innovative biologics, materials, processes, implants, devices, and informatics systems to be used for the prevention, diagnosis, and treatment of disease. DOE's Biomedical Engineering Program will complement other Federal programs by supporting early stage research at the national laboratories that cannot be funded by other Agencies.

Scientific and Technical Workforce Retention and Recruitment – During 1999, DOE conducted a systematic analysis of critical staffing needs within the context of current and projected R&D program missions. As a result, staffing shortfalls were identified, especially in scientific and technical disciplines. The Department will focus on building and sustaining a talented and diverse workforce of R&D Technical Managers through innovative recruitment strategies, retention incentives, comprehensive training and development programs, and succession planning.

The Office of Science, utilizing Program Direction funds, will recruit experienced scientists and related support staff in areas important to the Department's science mission. Other key activities to be supported include motivating and retaining highly skilled, top-performing technical managers, and the training of new and current scientists.

The Number of Graduate Students and Post Doctoral Investigators Supported

	Research Support	at User Facilities
FY 1999	6,550	4,840

Recent Office of Science Successes:

- Contributed 16% of the first one billion base pairs of human DNA sequence deposited in public databases by the human genome project.
- Advanced theoretical physics by demonstrating and verifying that all known "string" theories are equivalent.

- Developed and made publicly available the numerical linear algebra libraries on which today's high performance computers rely. These libraries represent decades of research.
- Observed the formation of two new chemical elements (numbers 116 and 118) at the LBNL's 88-Inch Cyclotron.
- Developed a rapid, efficient, self-assembly process for making "nanocomposite" materials, clearing the way for new materials with unprecedented mechanical properties.
- Advanced our understanding of tearing and reconnection in magnetic fields. This is important in many areas of fusion science, including understanding the eruptions of energetic bursts from the surface of the sun.

In addition, hundreds of principal investigators funded by SC have won dozens of major prizes and awards sponsored by the President, the Department, the National Academy of Sciences (NAS), the National Academy of Engineering, and the major professional societies.

Major Program Activities for FY 2001:

The **Basic Energy Sciences** (BES) program is one of the nation's major sponsors of fundamental research in broad areas of materials sciences, chemical sciences, geosciences, plant and microbial sciences, and engineering sciences. This program encompasses more than 2,400 researchers in 200 institutions and 17 of the nation's outstanding user facilities. BES principal investigators are recognized through the receipt of dozens of major prizes and awards from the scientific community.

The BES program has taken a leadership role in defining and addressing the 21st century challenges facing the physical and biological sciences – from understanding collective effects in materials to designing new materials atom by atom and, finally, to developing functional materials. This work underpins the nanoscale science, engineering, and technology initiative. In addition, BES will support construction of the Spallation Neutron Source and ongoing enhancements and maintenance activities at existing reactor and spallation neutron sources and synchrotron light sources.

The BES FY 2001 request supports the Climate Change Technology Initiative (CCTI) emphasizing fundamental research in sequestration science, science for efficient technologies, and fundamental science to advance low- and no-carbon energy sources. Examples include such diverse topics as: high-temperature materials for more efficient combustion; magnetic materials that reduce energy loss during use; semiconductor materials for solar-energy conversion; the foundations to enable evaluation of carbon dioxide sequestration in subsurface geologic formations; and the biological process of photosynthesis, which is central to global carbon cycling.

BES plays a central role in several of the SC priorities for FY 2001 described previously including the construction of the Spallation Neutron Source, enhanced Scientific Facility Utilization, and the National Nanotechnology Initiative. FY 2001 funding also is being requested in BES for fundamental research on microbial biochemistry. Microbes have dramatic impacts on energy production and conservation. The knowledge of the complex interactions that collectively characterize the life and function of these simplest of life forms will permit the control, modification, and use of microbes for both natural and industrial energy-related applications.

BES will also increase its investments in Robotics and Intelligent Machines for future applications important to DOE missions and to enable remote access to the SC user facilities.

The **Biological and Environmental Research** (BER) program has, for over 50 years, invested in advanced environmental and biomedical research to develop knowledge connected to energy. Fundamental research in genomics, structural biology, medical imaging, biomedical engineering, global climate change, and bioremediation at national laboratories, universities, and private institutions, BER develops the knowledge needed to identify, understand, and anticipate the long-term health and environmental consequences of energy production, development and use.

The scientific user facilities supported by BER provide unique capabilities for research in such key areas as structural biology and environmental science. Expanded funding for scientific facilities utilization will assure access to these facilities by scientists in universities, federal laboratories, and industry and will leverage both federally and privately sponsored research.

Construction of a new facility, the Laboratory for Comparative and Functional Genomics will be initiated at Oak Ridge National Laboratory. This facility will support high throughput determination of gene function in the mouse, a minimal model that is a key component of the Department's genome program.

In FY 2001, BER will continue to support basic research that contributes to interagency programs on the global impacts of and solutions for excess carbon in the environment - CCTI and the U.S. Global Change Research Program (US/GCRP).

The BER CCTI program is focused on carbon sequestration through enhancement of the natural terrestrial carbon cycle and sequestration of carbon in the oceans. The BER program complements carbon sequestration programs in BES and the DOE Office of Fossil Energy that focus primarily on other options for carbon sequestration.

FY 2001 will bring the first substantive research results from two new carbon sequestration sites that started collecting data at the end of FY 1999. Individual research projects at universities and national laboratories, started in FY 2000 and FY 2001, will also begin to yield results. The DNA sequences of four microorganisms that play prominent roles in the natural carbon cycle will have been determined. Structural biology studies will be conducted on the enzymes that regulate the processing of carbon in these four microbes to understand the molecular details of, and possibly to modify, these enzymes. Additional microbes with potential utility for enhanced carbon sequestration will also undergo DNA sequencing.

BER will initiate the Microbial Cell Project and expand its Biomedical Engineering Program as part of the Department's Life Sciences effort.

The **High Energy Physics** (HEP) program is directed at understanding the nature of matter and energy at the most fundamental level and the basic forces that govern all processes in nature. Fundamental research provides the foundation for our technology driven economy and advances the technically challenging missions of the Department of Energy.

The HEP FY 2001 request takes into consideration the recommendations of the High Energy Physics Advisory Panel's Gilman Report entitled "Planning for the Future of High-Energy Physics" (1998) through participation in the LHC project, increased support of university researchers, and optimum utilization of U.S. facilities.

The Fermilab 800 GeV fixed target program will complete data collection in FY 2000. Also in FY 2000, the Main Injector project was completed on schedule and within budget. The primary focus of the FY 2001 Fermilab program will be on Tevatron collider experiments that take advantage of the higher luminosity of the new Main Injector.

The SLAC B-factory was brought into full operation in FY 2000 on schedule and within budget. It has already recorded a world record peak luminosity of 2.7×10^{33} which is very close to the design luminosity of 3×10^{33} and an outstanding achievement for such a complex machine. In FY 2001 the B-factory will be operated for the BaBar experiment to collect data aimed at understanding matter-antimatter asymmetry.

The Alternating Gradient Synchrotron (AGS) at BNL was transferred from HEP to the Nuclear Physics Program in the 3rd Quarter of FY 1999 for use as part of the Relativistic Heavy Ion Collider (RHIC) facility. Limited operation of the AGS for HEP research is continuing in FY 2000 on an incremental cost basis. The high priority muon magnetic moment experiment took data in FY 2000 and will be completed during FY 2001. A follow-on experiment regarding the rare kaon will be supported in FY 2001.

The HEP program, in partnership with NSF, oversees U.S. participation in the Large Hadron Collider (LHC) at the European Laboratory for Particle Physics (CERN). HEP program funds were provided to support R&D, design and engineering work on the subsystems and components to be provided by the U.S. under the DOE-NSF agreement with CERN. The FY 2001 request for HEP includes $70 million for continued R&D, prototyping, setting up for production of accelerator components and ramping-up of production of detector subsystems. This work is part of the $450 million DOE contribution to the LHC effort negotiated with CERN.

Following the recommendations of the Gilman Report adopted by HEPAP, R&D will be continued on NLC with the goal of significantly reducing costs by applying such techniques as "design for manufacture". Fermilab has joined the R&D effort, which now involves four laboratories with SLAC as the lead laboratory and Fermilab, LBNL, and LLNL as partners.

The **Nuclear Physics** (NP) program provides primary support in the U.S. for fundamental research on the structure and interactions of atomic nuclei and the fundamental forces and particles of nature as manifested in nuclear matter. The NP program operates large and small research facilities located at DOE's national laboratories and research universities to provide microscopic probes of nuclear structures and forces.

The NP program works in close coordination with the Nuclear Physics program at the NSF and, jointly with NSF, charters the Nuclear Science Advisory Committee (NSAC) to provide advice on scientific opportunities and priorities. Construction of the Relativistic Heavy Ion Collider (RHIC) at BNL was completed in FY 1999 on schedule and within budget. Following initial operation and commissioning in FY 2000, RHIC will achieve full operation in FY 2001. Four detectors (STAR, PHENIX, BRAHMS and PHOBOS), involving over 950 researchers and students from 80 institutions and 19 nations, will allow a vigorous research program. The BNL Medium Energy Group will be re-directed in FY 2001 to concentrate on utilizing the new RHIC capabilities to investigate the origin of proton spin.

In FY 1999 the Isotope Separation On-Line Task Force, a subcommittee of NSAC, identified an optimal configuration for a next generation Rare Isotope Accelerator (RIA) facility. This facility was identified in the 1999 NSAC Long Range Plan for Nuclear Science as the highest priority for new construction. RIA R&D and preconceptual design activities continue in FY 2000 and FY 2001.

The U.S./Canadian Sudbury Neutrino Observatory (SNO) detector was completed in FY 1999. Data will be taken in FY 2000 and FY 2001 and initial measurements of solar neutrinos, relevant to the question of whether neutrinos have mass, are anticipated in FY 2001.

The Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab will increase beam energy to 6 GeV in FY 2001, enabling experiments to discern objects 50% smaller than the current operating energy. This will allow important new research that is not currently possible at CEBAF and much of the planned research program to be carried out twice as fast.

The BLAST detector at the MIT/Bates Linear Accelerator Center will be completed in FY 2001 and will initiate its research program, which will utilize high current continuous beams in the new South Hall Pulse Stretcher Ring.

The **Fusion Energy Sciences** (FES) program is the nation's primary sponsor of research in fusion science and plasma physics. It is a multi-purpose, research effort, producing valuable scientific knowledge and technological benefits in the near term and providing the science base for a fusion energy option in the long term. In FY 2001, FES will continue to make progress in: understanding the physics of plasmas; identifying and exploring innovative and cost-effective development paths to fusion energy; and exploring the science and technology of energy producing plasmas.

An integrated FES program plan will be completed during FY 2000. This plan will incorporate the findings and recommendations of the Secretary of Energy Advisory Board and National Research Council reviews as well as the technical understandings of the Fusion Energy Sciences Advisory Committee’s assessment of the program and the 1999 Fusion Summer Study.

The FES program will continue to operate three significant user facilities: DIII-D at General Atomics, Alcator C-Mod at MIT, and NSTX at the Princeton Plasma Physics Laboratory (PPPL). Scientists from universities, industry, and national laboratories will continue world class experiments at DIII-D and Alcator C-Mod on advanced tokamak modes of operation. A team of scientists will conduct pioneering experiments on NSTX, a medium-scale spherical torus, which may lead to a more cost-effective development path to fusion energy. A DOE-NSF partnership in Basic Plasma Science and Engineering will continue, including a joint announcement to be issued in FY 2000 for new funding opportunities in FY 2001.

Operation of the Massachusetts Institute of Technology Levitated Dipole Experiment will begin in FY 2000, bringing the total number of exploratory level alternative concept experiments operating in the U.S. to 13. This important new investment is expected to pay dividends in the form of improved understanding of magnetic confinement concepts over the next decade.

The FES program also includes an increased effort on heavy ion accelerator physics aimed at a driver for inertial fusion. Successful completion of experiments using modular systems will lead to the design of an Integrated Research Experiment, a proof-of-principle inertial fusion energy facility.

The FES program continues to work toward improving the scientific and programmatic coordination between the magnetic and inertial elements of the program. Bilateral and multilateral science and technology research activities on major scientific facilities abroad will enable U.S. scientists to access plasma conditions not readily available on domestic facilities.

A Virtual Laboratory for Technology uses the internet to integrate all of the enabling technology R&D elements into a coordinated national program. Research will continue on low activation materials, high heat flux component systems, and magnetic, heating and fueling components.

The **Advanced Scientific Computing Research** (ASCR) program’s primary mission is to discover, develop, and provide to researchers in various scientific disciplines the computational and networking tools that enable them to analyze, model, simulate, and predict complex phenomena important to the Department of Energy.

To accomplish this mission, the program fosters and supports fundamental research in advanced computing research – applied mathematics, computer science, and networking – and operates supercomputer, networking, and related facilities.

These have played a critical role in the evolution of high performance computing and networks.

The Mathematical, Information, and Computational Sciences (MICS) subprogram is responsible for carrying out the primary mission of the ASCR program. In all of the areas in which MICS supports research, the mission requirements far exceed the current state-of-the-art and the tools that the commercial marketplace can deliver. For this reason, the MICS subprogram is carefully managed to: integrate basic research; transform basic research results into software that can be transferred to scientists in other disciplines; and partner with users in scientific disciplines to validate the usefulness of the approach.

In FY 2001 the MICS subprogram will enhance its efforts to produce scientific computing, networking and collaboration tools needed by DOE researchers. These efforts will: increase access to multi-teraflop computers; establish a number of centers focused on the software challenges confronting terascale users; build partnerships between mathematicians, computer scientists, and scientists in other disciplines to produce advanced scientific software; tie together the physical and software services via common software framework building blocks ("middleware") to enable the success of the unique, data intensive, collaboratories of the future; and make significant contributions to the nation's Information Technology Research and Development effort.

MICS is changing the way it allocates resources at NERSC in the 21st century. The new allocation procedure proscribes that 60% of the resources will continue to be allocated directly by the SC program offices to research that they have peer reviewed. 40% of the resources will be allocated based on an independent peer review of proposals for high performance computing resources in a manner similar to the way other DOE user facilities allocate resources.
The FY 2001 request for the ASCR program also supports the Laboratory Technology Research subprogram, whose mission is to foster and support high-risk research in the natural sciences and engineering in partnership with the private sector leading to innovative applications relevant to the nation's energy sector.

The **Multiprogram Energy Laboratories - Facilities Support** (MELFS) program supports line items construction projects to replace and upgrade the general purpose infrastructure of the 5 SC multiprogram labs. The program also provides Payment in-lieu of Taxes to local communities around ANL and BNL; and, provides landlord support of the Oak Ridge Reservation and Operations Office.

The SC multiprogram labs are all over 50 years old and infrastructure investments are needed to ensure that the general purpose infrastructure supports the Department's research needs in a safe, environmentally sound, reliable, productive and cost-effective manner now and into the future. The FY 2001 budget will provide for 5 new utility related projects at LBNL, BNL and ORNL including water distribution systems, heating and ventilation systems, fire protection, electrical systems and surface and groundwater protection.

The **Science Program Direction** budget consists of three subprograms: Program Direction, Science Education, and Field Operations. Program Direction pays for the Federal staff and key support activities that provide the programmatic guidance within the Office of Science at headquarters. It also supports program-specific staff directly involved in executing SC programs at the Chicago, Oakland, and Oak Ridge Operations Offices. In FY 2001 there will be continued emphasis on integrated business management technology initiatives and supporting the ongoing efforts begun in FY 2000 related to succession planning and increasing diversity of the workforce. In addition, resources will be devoted to support the Department's Scientific and Technical Workforce Retention and Recruitment effort.

Scientific and Technical Workforce Retention and Recruitment focuses on building and sustaining a talented and diverse workforce of Research and Development (R&D) Technical Managers. During 1999, DOE conducted a systematic analysis of critical staffing needs within the context of R&D program missions, which identified current and projected staffing shortfalls, especially in scientific and technical disciplines. The Department will include innovative recruitment strategies, retention incentives, and comprehensive training and development programs for new and current employees, and succession planning. The FY 2001 program direction request for the Office of Science includes $2.0 million for this Scientific and Technical Workforce Retention and Recruitment effort. These funds will enable the Office of Science to recruit experienced scientists and related support staff in areas important to the Department's science mission, motivate and retain top-performing technical managers, and provide training in areas crucial for effective job performance.

The Science Education subprogram has as its mission to foster the next generation of scientists and engineers. A recent National Science Foundation (NSF) survey documents a five-year decrease in the number of science and engineering graduate students. Other studies indicate that the number of S&E graduates taking government positions is also sharply down. Science Education activities enable college and university students and faculty to take advantage of fellowship and research opportunities at the national laboratories and user facilities. Such initiatives are tailored to recruit and retain students interested in science and engineering. Science Education also sponsors the Energy Research Undergraduate Laboratory Fellowship Program, the Albert Einstein Distinguished Educator Fellowship Program and the National Science Bowl®. The DOE Institute of Biotechnology, Environmental Science, and Computing for Community Colleges is also sponsored within Science Education. This is the result of a successful pilot in 1999. All of these efforts are designed to ensure that the next generation of scientists and engineers accept careers in and meet the challenges of fundamental science, energy, the environment, and national security.

Field Operations funds the core management and administrative Federal staff and the related operational costs at three of the Department's multi-program Operations Offices that report to SC: Chicago, Oakland, and Oak Ridge. This account provides the resources necessary to support the scientific and technical work performed on behalf of Science and other DOE programs within the field/laboratory structure. These resources will support integrated business management systems aimed at providing coordinated, efficient and effective services and process improvements.

The 5% cut in FY 2000 funding for field operations combined with the reorganization of field management has had an impact on SC's ability to manage our programs. With the new organization, SC is confident in our ability to efficiently and effectively manage the field within requested funding.

The **Technical Information Management** (TIM) program maximizes the return on DOE's $7 billion annual R&D investment by collecting, preserving, and disseminating information resulting from these research programs. This information is recorded in three forms: journals, technical reports, and pre-prints. The TIM program has produced world-class web-based systems to provide full-text, electronic access to all three sources of information. The DOE Information Bridge (www.doe.gov/bridge) provides access to 70,000 technical reports. The newly launch PubScience (www.doe.gov/pubsci) provides electronic access to over 1,000 physical science journals – analogous to the capability PubMed provides in the life sciences.

FY 2001 accomplishments will include expanded coverage of science journals and a fully operational, searchable pre-print network. Also, the TIM program will continue its important role in obtaining foreign research information through two international information exchanges and, for the first time, will provide access to this information in electronic full-text. Finally, the program will provide enhanced protection and secure electronic access to a 50-year old repository of classified and sensitive R&D information.

Closing:

The reduction of FY 2000 funds for contractor travel is having a significant impact on our ability to conduct forefront research in the fundamental sciences. The advance of research is greatly aided by the exchange of ideas and the sharing of experiences. In many of the disciplines supported by the Office of Science, important exchanges take place at national and international scientific meetings and through interpersonal exchanges. Reductions in contractor travel have hampered these exchanges and have impacted SC's ability to recruit young scientists to the national laboratories.

James Decker
Director (Acting)
Office of Science

Table 1

OFFICE OF SCIENCE
FY 2001 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

	FY 1999 Conf. Approp.	FY 2000 Conf. Approp.	FY 2001 Pres. Request
Science			
Basic Energy Sciences	783,185	771,561	1,015,770
Advanced Scientific Computing Research	153,512	127,883	181,970
Biological and Environmental Research	425,890	432,886	445,260
Fusion Energy Sciences	217,248	244,686	247,270
High Energy Physics	680,716	697,743	714,730
Nuclear Physics	327,168	347,714	369,890
Energy Research Analyses	976	991	1,000
Multiprogram Energy Laboratories-Facilities Support	21,260	33,055	33,930
Science Program Direction	49,453	131,108	141,245
Small Business Innovation Research and Small Business Technology Transfer	81,461	-	-
Subtotal	2,740,869	2,787,627	3,151,065
General Reduction for Use of Prior Year Balances	(13,000)	-	-
Superconducting Super Collider	(7,600)	-	-
Total	2,720,269	2,787,627	3,151,065
Energy Supply R&D			
Technical Information Management	8,836	8,600	9,302
Small Business Innovation Research and Small Business Technology Transfer	4,874	-	-
General Reduction for Use of Prior Year Balances	(250)	-	-
Total	13,460	8,600	9,302

Table 2

OFFICE OF SCIENCE
FY 2001 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

	FY 1999 Conf. Approp.	FY 2000 Conf. Approp.	FY 2001 Pres. Request
Global Climate Change	111,608	119,901	122,347
Climate Change Technology Initiative	13,500	33,000	36,700
Science and Education Programs	4,500	4,500	6,500
Nanoscience Engineering and Technology	-	47,660	83,595
Robotics and Intelligent Machines	-	700	2,700
Microbial Cell Research	-	-	12,500
Bioengineering Research	-	1,700	6,700

Table 3

OFFICE OF SCIENCE
FY 2001 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

Major Site Funding	FY 1999 Conf. Approp.	FY 2000 Conf. Approp.	FY 2001 Pres. Request
AMES LABORATORY			
Advanced Scientific Computing Research	2,239	1,672	1,571
Basic Energy Sciences	18,838	16,990	16,165
Biological and Environmental Research	900	660	525
Total Laboratory	21,977	19,322	18,261
ARGONNE NATIONAL LABORATORY			
Advanced Scientific Computing Research	19,032	12,187	11,958
Basic Energy Sciences	144,752	140,005	160,726
Biological and Environmental Research	10,198	9,040	20,780
Fusion Energy Sciences	2,604	2,339	2,270
High Energy Physics	9,679	9,702	11,055
Multiprogram Energy Labs-Facilities Support	7,089	4,980	6,660
Nuclear Physics	17,039	16,304	16,965
Science Program Direction	797	200	900
Total Laboratory	211,190	194,757	231,314
BROOKHAVEN NATIONAL LABORATORY			
Advanced Scientific Computing Research	2,023	1,811	1,504
Basic Energy Sciences	79,425	75,441	75,769
Biological and Environmental Research	23,413	19,163	16,758
Energy Research Analyses	48	50	-
High Energy Physics	69,514	30,990	38,844
Multiprogram Energy Labs-Facilities Support	1,349	6,881	6,659
Nuclear Physics	117,305	132,463	145,783
Science Program Direction	398	250	600
Total Laboratory	293,475	267,049	285,917

Major Site Funding	FY 1999 Conf. Approp.	FY 2000 Conf. Approp.	FY 2001 Pres. Request
THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY			
Advanced Scientific Computing Research	151	50	200
Biological and Environmental Research	260	-	-
Nuclear Physics	71,673	72,730	74,715
Science Program Direction	-	-	150
Total Laboratory	72,084	72,780	75,065
FERMI NATIONAL ACCELERATOR LABORATORY			
Advanced Scientific Computing Research	213	60	200
Energy Research Analyses	-	-	60
High Energy Physics	296,713	286,253	282,730
Total Laboratory	296,926	286,313	282,990
IDAHO NATIONAL ENGINEERING LABORATORY			
Basic Energy Sciences	3,709	2,674	3,121
Biological and Environmental Research	2,084	1,761	1,489
Fusion Energy Sciences	1,804	1,623	1,701
Nuclear Physics	80	-	-
Total Laboratory	7,677	6,058	6,311
LAWRENCE BERKELEY NATIONAL LABORATORY			
Advanced Scientific Computing Research	57,969	53,865	64,457
Basic Energy Sciences	66,080	63,386	68,537
Biological and Environmental Research	39,163	43,581	40,532
Energy Research Analyses	165	30	75
Fusion Energy Sciences	4,971	7,877	7,655
High Energy Physics	26,706	33,627	37,786
Multiprogram Energy Labs-Facilities Support	4,854	6,133	2,113
Nuclear Physics	23,222	17,232	17,250
Science Program Direction	309	225	500
Total Laboratory	223,439	225,956	238,905

Major Site Funding	FY 1999 Conf. Approp.	FY 2000 Conf. Approp.	FY 2001 Pres. Request
LAWRENCE LIVERMORE NATIONAL LABORATORY			
Advanced Scientific Computing Research	3,620	3,210	3,160
Basic Energy Sciences	6,618	6,336	6,195
Biological and Environmental Research	41,127	40,110	38,875
Fusion Energy Sciences	11,696	13,063	12,716
High Energy Physics	1,496	1,230	850
Nuclear Physics	710	564	785
Total Laboratory	65,267	64,513	62,581
LOS ALAMOS NATIONAL LABORATORY			
Advanced Scientific Computing Research	15,206	11,873	10,560
Basic Energy Sciences	24,950	24,427	27,861
Biological and Environmental Research	22,362	19,280	17,971
Fusion Energy Sciences	4,365	6,094	5,960
High Energy Physics	870	860	800
Nuclear Physics	10,505	9,986	10,095
Total Laboratory	78,258	72,520	73,247
OAK RIDGE NATIONAL LABORATORY			
Advanced Scientific Computing Research	13,392	7,584	6,719
Basic Energy Sciences	221,267	207,551	372,644
Biological and Environmental Research	28,062	25,988	29,144
Energy Research Analyses	-	40	40
Fusion Energy Sciences	18,093	17,550	17,621
High Energy Physics	240	240	240
Multiprogram Energy Labs-Facilities Support	6,808	1,101	6,627
Nuclear Physics	16,094	15,173	16,120
Science Program Direction	439	320	800
Total Laboratory	304,395	275,547	449,955

Major Site Funding	FY 1999 Conf. Approp.	FY 2000 Conf. Approp.	FY 2001 Pres. Request
PACIFIC NORTHWEST NATIONAL LABORATORY			
Advanced Scientific Computing Research	4,312	2,602	2,210
Basic Energy Sciences	12,887	12,063	12,295
Biological and Environmental Research	79,879	64,339	65,312
Energy Research Analyses	250	250	300
Fusion Energy Sciences	1,415	1,385	1,385
High Energy Physics	10	-	-
Science Program Direction	572	275	750
Total Laboratory	99,325	80,914	82,252
NATIONAL RENEWABLE ENERGY LABORATORY			
Advanced Scientific Computing Research	127	-	-
Basic Energy Sciences	4,492	5,180	5,116
Total Laboratory	4,619	5,180	5,116
PRINCETON PLASMA PHYSICS LABORATORY			
Advanced Scientific Computing Research	121	45	200
Basic Energy Sciences	675	-	-
Fusion Energy Sciences	52,129	62,970	70,219
High Energy Physics	120	120	120
Science Program Direction	-	-	250
Total Laboratory	53,045	63,135	70,789
SANDIA NATIONAL LABORATORY			
Advanced Scientific Computing Research	5,651	4,798	4,705
Basic Energy Sciences	27,142	23,075	23,879
Biological and Environmental Research	3,537	1,490	3,091
Energy Research Analyses	-	50	75
Fusion Energy Sciences	4,120	3,338	3,232
Total Laboratory	40,450	32,751	34,982

Major Site Funding	FY 1999 Conf. Approp.	FY 2000 Conf. Approp.	FY 2001 Pres. Request
STANFORD LINEAR ACCELERATOR CENTER			
Advanced Scientific Computing Research	1,052	375	450
Basic Energy Sciences	26,475	23,042	31,592
Biological and Environmental Research	2,771	2,450	3,500
Fusion Energy Sciences	50	50	-
High Energy Physics	146,559	151,377	157,257
Science Program Direction	15	-	150
Total Laboratory	176,922	177,294	192,949

High Energy Physics

Program Mission

The High Energy Physics (HEP) program of the Department of Energy (DOE) has the lead responsibility for Federal support of high energy physics research and supports fundamental research activities under the mandate provided in Public Law 95-91 which established the Department. The High Energy Physics program is a key element in the Science and Technology component of the DOE Strategic Plan, supporting several of the strategies which make up that component. This program is also one of the identified elements in the Secretary's Performance Agreement with the President, and is an integral part of the Department's fundamental research mission. The program is directed at understanding the nature of matter and energy at the most fundamental level, and the basic forces which govern all processes in nature. Fundamental research provides the necessary foundation that ultimately enables the Nation to progress in its science and technology capabilities, to advance its industrial competitiveness, and to discover new and innovative approaches to our energy future.

The high quality of the research in this program is continuously evaluated through the use of merit based peer review and scientific advisory committees.

Program Goal

Provide new insights into the nature of energy and matter to better understand the natural world.

Program Objectives

- *To continue to support high quality research*—Support high quality university and laboratory based high energy physics research, both theoretical and experimental. Experimental research is primarily performed by university scientists using particle accelerators located at major laboratories in the U.S. and abroad.
- *To effectively operate the department's high energy physics accelerator facilities*—Provide optimal and cost effective operation for research of the Fermi National Accelerator Laboratory, and the Stanford Linear Accelerator Center. The Alternating Gradient Synchrotron (AGS) complex at the Brookhaven National Laboratory was transferred to the Nuclear Physics (NP) program during FY 1999. HEP use of the AGS will continue on an incremental cost basis.
- *To continue to provide world class research facilities*—Plan for and build new, state-of-the-art research facilities that allow researchers to advance the forefront of the science of high energy physics. Support essential improvements and upgrades at the major accelerator laboratories. Manage the commissioning of the Fermilab Main Injector project, the initial operation of the B-factory at SLAC and the continuation of the new experimental facility at Fermilab called Neutrinos at the Main Injector (NuMI).
- *To continue to provide the program's technological base*—Support long-range accelerator and detector R&D required to provide the advanced concepts and technologies that are critical to the long-range viability of high energy physics research.

- *To continue to pursue international collaboration on large high energy physics projects*—Using the management and control systems already put into place, work to successfully carry out the planned and agreed to collaboration with CERN on the Large Hadron Collider (LHC) project. Work to explore and pursue other opportunities for effective and beneficial international collaborative activities.

Performance Measures

Performance measures related to basic science activities are primarily qualitative rather than quantitative. The scientific excellence of the High Energy Physics program is continually reevaluated through the peer review process. Some specific performance measures are:

- Quality of scientific results and plans as indicated by expert advisory committees, recognition by the scientific community, and awards received by DOE-supported High Energy Physics researchers. The results of these reviews and other quality measures will be used to determine programmatic directions aimed at maintaining the world leadership position of the U.S. high energy physics program.
- Sustained achievement in advancing knowledge, as measured by the quality of the research based on results published in refereed scientific journals, and by the degree of invited participation at national and international conferences and workshops.
- Operation of research facilities in a manner that meets user requirements, as indicated by achieving performance specifications while protecting the safety of the workers and the environment, and by the level of endorsement by user organizations; operating facilities that are used for research at the forefront of science; and operating facilities reliably and according to planned schedules. In FY 2001, High Energy Physics will be operating the B-factory at SLAC, the Main Injector for the Tevatron at Fermilab, and using the AGS at BNL.
- Progress on achieving luminosity and operational efficiency for the B-factory at SLAC as measured by comparison with stated project goals.
- Progress on maintaining luminosity and operational efficiency for the Tevatron at Fermilab in its new mode of operation with the recently completed Main Injector.
- The upgrade of scientific facilities will be managed to keep them on schedule and within cost.
- Deliver on the scheduled U.S./DOE commitments to the international Large Hadron Collider project.
- Review at least 80 percent of the research projects by appropriate peers; continue to select research projects through a merit-based competitive process.
- Meet on time and within budget the scheduled U.S. DOE commitments to the international Large Hadron Collider project as reflected in the latest international agreement and corresponding plan.
- Make progress on the Neutrinos at the Main Injector project as measured by accomplishment of scheduled milestones as detailed in the benchmark plan.
- High Energy Physics plans and research will be recognized as outstanding by expert advisory committees such as the High Energy Physics Advisory Panel (HEPAP) and through other rigorous peer review. Additionally, the scientific results will be recognized through the awards received by its researchers and by the broader scientific community.

Significant Accomplishments and Program Shifts

- The long range planning study of the High Energy Physics program was prepared in 1998 by a Subpanel of the High Energy Physics Advisory Panel (HEPAP), (Gilman report). Their report is entitled "Planning for the Future of U.S. High-Energy Physics." The Subpanel's recommendations were considered carefully in preparing this budget.
- In FY 1999, the following performance goals were fully met:
  - Continue collaborative efforts with NASA on space science and exploration.
  - Deliver on the 1999 US/DOE commitments to the international LHC project.

Research and Technology

- In FY 1997, a test of a superconducting accelerator-style magnet fabricated at Lawrence Berkeley National Laboratory (LBNL) achieved a field strength of greater than 11 teslas in a new rectangular geometry with no quenches. This is a significant accomplishment in the effort to advance technology for future accelerators.

The following were accomplished in FY 1999:

- Measurement, by teams of university and laboratory scientists working at Fermilab, of the mass and production properties of the top quark was accomplished. This is the last, and by far the heaviest, of the fundamental building blocks of matter (quarks) whose existence was predicted by the Standard Model of elementary particles. The mass of the top quark is now measured more accurately than that of any of the other quarks. Further refinement of this result are continuing, and will improve even more with data from the upcoming run of the Tevatron with the newly upgraded Main Injector.
- The world's most precise measurement was made, by a team of university and laboratory scientists working at Fermilab, of the mass of the W boson. This result is now considerably more precise than the best measurement from LEP. It will improve even more with data from the upcoming run of the Tevatron with the newly upgraded Main Injector.
- The world's highest precision single measurement of the weak mixing angle, a fundamental parameter of the Standard Model, was made by a group of university and laboratory scientists working at SLAC with the Stanford Large Detector (SLD). The final result from the final data run has now been obtained.
- The observation was made, by the international CDF collaboration working at Fermilab, of the existence and properties of the B meson containing a charmed quark. This discovery completes the theoretically predicted family of B mesons.
- The observation of direct violation of CP symmetry in the decays of K mesons was made by a team of university and laboratory scientists working at Fermilab. More data is being analyzed to refine this result.
- The observation was made for the first time ever by the KTeV collaboration of the predicted decay of the kaon into a pair of pions and an electron-positron pair. Further refinement of this result was achieved.
- A major advance in theoretical physics was achieved when it was shown and verified that all of the known "string" theories are equivalent. This greatly reduces the number of possible theories which

describe all of the known forces including gravity. Further work toward delineating the underlying theory from which all string theories originate is continuing at a fast pace.

- A SLAC 30 GeV electron beam was directed down a 1.5 meter Lithium plasma creating a plasma wave that exhibited an accelerating gradient of greater than 0.5 GeV per meter, a record in this highly speculative program that may have a potential of approaching10's of GeV per meter accelerating gradient eventually.
- At the g-2 experiment at BNL, designed to study the magnetic properties of the muon, the most precise measurement of the anomalous magnetic moment has been obtained. Initial data collection has been completed and more data is being analyzed. Even more data should become available over the next two years. The experimenters are confident that they will achieve the world's best measurements of the anomalous magnetic moment and lifetime of the muon in both positive and negative charge states. If the final results agree with the standard model, this will place significant limits on new physics beyond the standard model.
- DOE is entering into an exciting and expanding partnership with NASA in the area of Particle Astrophysics. R&D for the Antimatter in Space (AMS) and Gamma Large Area Space Telescope (GLAST) experiments has been underway for some time. Preliminary consideration is being given to the SuperNova Acceleration Probe (SNAP) experiment. These experiments, and others that may be proposed, will provide important new information about cosmic rays and the rate of expansion of the universe which will in turn lead to a better understanding of dark matter, dark energy, and the original big bang.
- Evidence of neutrino mass and quantum mixing was obtained in a U.S.-Japanese experiment with the Super-Kamiokande experiment in Japan. Further data and refinement of these results was achieved. Long baseline neutrino beam experiments in Japan and at Fermilab are underway to verify these results.

High Energy Physics Facilities

- The final data collection with the Fermilab 800 GeV fixed-target program is being completed in FY 2000, and in FY 2001 the prime focus of the Fermilab program will turn to research using the Tevatron collider with the higher luminosity of the new Main Injector.
- The B-factory at SLAC was brought into full operation during FY 2000, and in FY 2001 will be operated for the BaBar experiment to collect data aimed at understanding matter-antimatter asymmetry as evidenced in the B-meson systems.
- The Alternating Gradient Synchrotron at BNL was transferred to the Nuclear Physics program for operation as the injector for the RHIC facility during the 3rd quarter of FY 1999. Beginning in FY 2000 AGS operation for High Energy Physics experiments is on an incremental cost basis. Limited operation of the AGS for HEP research is continuing on a non-interfering and incremental cost basis. The high priority muon magnetic moment experiment is taking data in FY 2000 and will be completed during FY 2001. A follow-on rare kaon experiment has been approved and will have a shake-down run in FY 2001.
- The Department is continuing research and development which will provide the basis for a reviewable technical design and cost estimate for a large electron-positron (antielectron) collider called the Next Linear Collider (NLC). The international high energy physics community has determined that such a machine is complementary to the Large Hadron Collider (LHC) now under

construction at the CERN Laboratory outside of Geneva, Switzerland, and essential if the issues of the physics beyond the Standard Model are to be effectively addressed. A formal endorsement was supplied in August 1999 in a statement on Linear Colliders issued by the International Committee of Future Accelerators (ICFA), sponsored by the Particles and Fields Commission of the International Union on Pure and Applied Physics (IUPAP):

> *"Scientific panels charged with studying future directions for particle physics in Europe, Japan, and the United States have concluded that there would be compelling and unique scientific opportunities at a linear electron-positron collider in the TeV energy range. Such a facility is a necessary complement to the LHC hadron collider now under construction at CERN. Experiment results over the last decade from the electron-positron colliders LEP and SLC combined with those from the Tevatron, a hadron collider, have led to this worldwide consensus.*
>
> *ICFA recommends continued vigorous pursuit of the accelerator research and development on a linear collider in the TeV energy range, with the goal of having designs complete with reliable cost estimates in a few years. We believe that an electron-positron collider optimized for the new physics should be built in a timely way with international participation."*

The technical basis for the advantages of electron-positron colliders is the precision associated with the fact that electrons and positrons are point particles (unlike the protons used in the LHC which are composites of three quarks), the more favorable secondary particle backgrounds, and the polarization (alignment of spin) of the electrons which adds a dimension of physics exploration not available with the LHC.

The R&D program is directed at a center-of-mass energy capability in the 500 to 1000 GeV (1 TeV) range, expandable to 1.5 TeV. This choice is based on the recommendations provided by the February 1998 report of the DOE HEPAP Subpanel on Planning for the Future of High Energy Physics which stated (Executive Summary):

> *"The Subpanel recommends that SLAC continue R&D with Japan's KEK toward a common design for an electron-positron linear collider with a luminosity of at least* 10^{34} $cm^{-2}s^{-1}$ *and an initial capability of 1 TeV in the center of mass, extendible to 1.5 TeV. The Subpanel recommends that SLAC be authorized to produce a Conceptual Design Report for this machine in close collaboration with KEK."*
>
> *"This is not a recommendation to proceed with construction. A decision on whether to construct a linear collider should only follow the recommendation of a future subpanel convened after the CDR is complete. The decision will depend on what is known about the technology of linear colliders and other potential facilities, costs, international support, and advances in our physics understanding."*

The specific goals of the present NLC R&D program include developing new technologies that enable a higher performance, lower cost machine; carrying out systems engineering, value engineering, and risk analysis studies to identify additional R&D issues that could effect cost and performance and to down-select from available technologies; and using industrial firms to carry out R&D on key technologies, thus exploiting the special "design-for-manufacture" expertise available in industry and effecting technical transfer from the NLC R&D program to industry. In addition there is development of cost analysis and scheduling tools that can be used to guide the R&D

program by identifying cost driving technologies and that will be essential at such time as a Conceptual Design Report is authorized.

The NLC R&D activities to be supported by DOE are carried out by a national collaboration that includes SLAC as the principle laboratory, Fermilab as the major collaborator, and with significant contributions from Lawrence Berkeley National Laboratory and Lawrence Livermore National Laboratory. The R&D is also part of an international collaboration that includes the Japanese high energy physics center, KEK, through a SLAC-KEK inter-laboratory memorandum of understanding, and by less formal arrangements, with R&D groups at the German DESY Laboratory, CERN, and the Budker Institute in Russia.

The proposed DOE HEP funding is $17,000,000 in FY 1999, $17,400,000 in FY 2000, and $19,200,000 in FY 2001.

- Support for the Waste Management activities at LBNL is initiated in FY 2001 with a transfer of funds and responsibility from Environmental Management to HEP as the landlord for LBNL.

- The European Center for Nuclear Research (CERN) in Geneva, Switzerland has initiated the Large Hadron Collider (LHC) project. This will consist of a 7 on 7 TeV proton-proton colliding beams facility to be constructed in the existing Large Electron-Positron Collider (LEP) machine tunnel (LEP will be removed). The LHC will have an energy 7 times that of the Tevatron at Fermilab. Thus the LHC will open up substantial new frontiers for scientific discovery.

  Participation by the U.S. in the LHC program is extremely important to U.S. High Energy Physics program goals. The LHC will become the foremost high energy physics research facility in the world around the middle of the next decade. With the LHC at the next energy frontier, American scientific research at that frontier depends on participation in LHC. The High Energy Physics Advisory Panel (HEPAP) Subpanel on Vision for the Future of High-Energy Physics (Drell) strongly endorsed participation in the LHC, and this endorsement has been restated by HEPAP on several occasions.

  The physics goals of the LHC include a search for the origin of mass as represented by the “Higgs” particle, exploration in detail of the structure and interactions of the top quark, and the search for totally unanticipated new phenomena. Although LHC will have a lower energy than the Superconducting Super Collider (canceled in 1993), it has strong potential for answering the question of the origin of mass. The LHC energies are sufficient to test theoretical arguments for a totally new type of matter. In addition, history shows that major increases in the particle energy nearly always yield unexpected discoveries.

  DOE and NSF have entered into a joint agreement with CERN about contributions to the LHC accelerator and detectors as part of the U.S. participation in the LHC program to provide access for U.S. scientists to the next decade’s premier high energy physics facility. The resulting agreements were approved by CERN, the DOE and the NSF and were signed in December of 1997.

  Participation in the LHC project (accelerator and detectors) at CERN will primarily take the form of the U.S. accepting responsibility for designing and fabricating particular subsystems of the accelerator and of the two large detectors. Thus, much of the funding will go to U.S. laboratories, university groups, and industry for fabrication of subsystems and components which will become part of the LHC accelerator or detectors. A portion of the funds will be used to pay for purchases by

CERN of material needed for construction of the accelerator. As a result of the negotiations, CERN has agreed to make these purchases from U.S. vendors.

The agreement provides for a U.S. DOE contribution of $450,000,000 to the LHC accelerator and detectors over the period FY 1996 through FY 2004 (with approximately $81,000,000 being provided by the NSF). The DOE contribution is broken down as follows: detectors $250,000,000; accelerator $200,000,000 (including $90,000,000 for direct purchases by CERN from U.S. vendors and $110,000,000 for fabrication of components by U.S. laboratories).

The total cost of the LHC on a basis comparable to that used for U.S. projects is estimated at about $6,000,000,000. Thus the U.S. contribution represents less than 10 percent of the total. (The LHC cost estimates prepared by CERN, in general, do not include the cost of permanent laboratory staff and other laboratory resources used to construct the project.) Neither the proposed U.S. DOE $450,000,000 contribution nor the estimated total cost of $6,000,000,000 include support for the European and U.S. research physicists working on the LHC program.

The agreement negotiated with CERN provides for U.S. involvement in the management of the project through participation in key management committees (CERN Council, CERN Committee of Council, LHC Board, etc.). This will provide an effective base from which to monitor the progress of the project, and will help ensure that U.S. scientists have full access to the physics opportunities available at the LHC. The Office of Science has conducted a cost and schedule review of the entire LHC project and similar reviews of the several proposed U.S. funded components of the LHC. All of these reviews concluded the costs are properly estimated and that the schedule is feasible.

In addition to the proposed U.S. DOE $450,000,000 contribution and $81,000,000 NSF contribution to the LHC accelerator and detector hardware fabrication, U.S. participation in the LHC will involve a significant portion of the U.S. High Energy Physics community in the research program at the LHC. This physicist involvement has already begun. Over 500 U.S. scientists have joined the U.S.-ATLAS detector collaboration, the U.S.-CMS detector collaboration, or the U.S.-LHC accelerator consortium, and are hard at work helping to design the initial physics research program to be carried out at the LHC helping to specify the planned physics capabilities of the LHC accelerator and detectors, and helping to design and fabricate accelerator and detector components and subsystems.

Fabrication of LHC subsystems and components by U.S. participants began in FY 1998. Funding was provided in FY 1996 ($6,000,000) and FY 1997 ($15,000,000) for preliminary R&D, design and engineering work on the subsystems and components being proposed for inclusion in the agreement with CERN. This funding was essential in order to provide the cost and technical bases for the proposed U.S. responsibilities in LHC, and to be ready for rapid start to satisfy the anticipated timetable for the project. Funding in the amount of $35,000,000 was provided in FY 1998, $65,000,000 was provided in FY 1999, $70,000,000 was provided in FY 2000, and $70,000,000 will be provided in FY 2001 to support continuation of these R&D and design efforts, and the continuation of fabrication of those subsystems and components specified in the agreements with CERN.

The planned U.S. Funding for the LHC project is summarized below:

U.S. LHC Accelerator and Detector Funding

(dollars in thousands)

Fiscal Year	Department of Energy			National Science Foundation[a]
	Accelerator	Detector	Total	
1996[b]	2,000	4,000	6,000	0
1997[b]	6,670	8,330	15,000	0
1998[b]	14,000	21,000	35,000	0
1999	23,491	41,509	65,000	22,150
2000	33,206	36,794	70,000	15,900
2001	36,303	33,697	70,000	16,370
2002	31,200	38,800	70,000	16,860
2003	29,000	36,000	65,000	9,720
2004	24,130	29,870	54,000	0
Total	200,000[c]	250,000	450,000	81,000

Construction

- The Research Office Building project at SLAC was started in FY 2000. When completed in FY 2002, it will provide much needed office and laboratory space for the outside groups collaborating on the BaBar experiment.
- The Wilson Hall Safety Improvements Project at Fermilab is proceeding well and is on schedule for completion in FY 2001. The project is remediating structural deficiencies and addressing safety issues resulting from aging building components and systems.
- The Neutrinos at the Main Injector (NuMI) Project is proceeding on schedule. The project will provide a new neutrino beamline aimed at the Soudan Underground Laboratory in Soudan, Minnesota where the large MINOS detector will be installed to search for and study neutrino oscillations.

[a] The NSF funding has been approved by the National Science Board.

[b] The FY 1996 and FY 1997 LHC funding was for R&D, design and engineering work in support of the proposed U.S. participation in LHC. Beginning in FY 1998 funding was used for: fabrication of machine and detector hardware, supporting R&D, prototype development, and purchases by CERN from U.S. vendors.

[c] Includes $110,000,000 for LHC supporting R&D and accelerator components to be fabricated by U.S. laboratories and $90,000,000 for purchases by CERN from U.S. vendors.

Scientific Facilities Utilization

The High Energy Physics request includes $441,521,000 to maintain support of the Department's scientific user facilities. This investment will provide significant research time for several thousand scientists in universities, and other Federal laboratories. It will also leverage both Federally and privately sponsored research, consistent with the Administration's strategy for enhancing the U.S. National science investment. The proposed funding will support operations at the Department's two major high energy physics facilities: the Tevatron at Fermilab, and the B-factory at the Stanford Linear Accelerator Center (SLAC). The Alternating Gradient Synchrotron (AGS) at the Brookhaven National Laboratory (BNL), is now part of the Nuclear Physics (NP) funded Relativistic Heavy Ion Collider (RHIC) complex and is being operated for HEP purposes on a limited basis.

Funding of Contractor Security Clearances

In FY 1999, the Department divided the responsibility for obtaining and maintaining security clearances. The Office of Security Affairs, which was responsible for funding all Federal and contractor employee clearances, now pays only for clearances of Federal employees, both at headquarters and the field. Program organizations are now responsible for contractor clearances, using program funds. This change in policy enables program managers to make the decisions as to how many and what level clearances are necessary for effective program execution. In this way, it is hoped that any backlog of essential clearances which are impeding program success can be cleared up by those managers most directly involved. The Office of Science is budgeting $270,000 in FY 2000 and in FY 2001 for estimated contractor security clearances within this decision unit.

Workforce Development

The national laboratories, with significant High Energy Physics programs, provide a wide range of facilities and services for users, as well as maintaining their own scientific staffs which perform high-energy physics research in collaboration with outside users. Operating accelerators which provide beams for experiments is the primary service for users for Fermilab National Accelerator Laboratory, the Stanford Linear Accelerator Laboratory, and the Brookhaven National Laboratory. Other critical functions include providing technical staff and facilities for the design and fabrications of experiments, computing resources required to analyze the large data samples generated by experiments, research and development for future accelerators, and a host of services to support a large body of resident users, which includes graduate students, post-docs, and visiting faculty.

Scientific productivity is evaluated through peer review. The quality and importance of scientific results cannot be reduced to simple numerical measures of arbitrarily defined quantities. The Division of High Energy Physics conducts reviews of all aspects of the High Energy Physics program, including the programs and operations of the national laboratories. Experts in relevant areas participate in these reviews. The peer review process not only provides evaluations of the scientific productivity of various components of the High Energy Physics program, but also provides advice and suggestions for making improvements. Such guidance is critical in determining future programmatic directions so that the U.S. can maintain its place as a world leader in high-energy physics research. In FY 1999, 1,142 graduate students and post doc investigators were supported by HEP; 630 of those students and investigators were working at HEP user facilities.

Funding Profile

(dollars in thousands)

	FY 1999 Current Appropriation	FY 2000 Original Appropriation	FY 2000 Adjustments	FY 2000 Current Appropriation	FY 2001 Request
High Energy Physics					
Research and Technology	214,891	229,190	0	229,190	237,720
High Energy Physics Facilities	444,825	450,000	-10,147	439,853	444,610
Subtotal, High Energy Physics	659,716	679,190	-10,147	669,043	682,330
Construction	21,000	28,700	0	28,700	32,400
Subtotal, High Energy Physics	680,716	707,890	-10,147	697,743	714,730
Use of Prior Year Balances	-1,610[a]	0	0	0	0
General Reduction	0	-6,001	6,001	0	0
Contractor Travel	0	-1,771	1,771	0	0
Omnibus Rescission	0	-2,375	2,375	0	0
Total, High Energy Physics	679,106[b]	697,743	0	697,743	714,730[c]

Public Law Authorization:

Public Law 95-91, “Department of Energy Organization Act”

Public Law 103-62, “Government Performance Results Act of 1993”

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $13,972,000 which has been transferred to the SBIR program and $838,000 which has been transferred to the STTR program.

[c] Includes $5,500,000 for Waste Management activities at Lawrence Berkeley National Laboratory that was previously budgeted in FY 1999 and FY 2000 in the Environmental Management program.

Funding by Site

	(dollars in thousands)				
	FY 1999	FY 2000	FY 2001	$ Change	% Change
Albuquerque Operations Office					
Los Alamos National Laboratory	870	860	800	-60	-7.0%
Albuquerque Operations Office	0	13	0	-13	-100.0%
Total, Albuquerque Operations Office.........	870	873	800	-73	-8.4%
Chicago Operations Office					
Argonne National Laboratory	9,679	9,702	11,055	+1,353	+13.9%
Brookhaven National Laboratory	69,514	30,990	38,844	+7,854	+25.3%
Fermi National Accelerator Laboratory .	296,713	286,253	282,730	-3,523	-1.2%
Princeton Plasma Physics Laboratory ..	120	120	120	0	0.0%
Chicago Operations Office..................	82,721	87,042	78,783	-8,259	-9.5%
Total, Chicago Operations Office...............	458,747	414,107	411,532	-2,575	-0.6%
Oakland Operations Office					
Lawrence Berkeley National Laboratory	26,706	33,627	37,786	+4,159	+12.4%
Lawrence Livermore National Laboratory	1,496	1,230	850	-380	-30.9%
Stanford Linear Accelerator Center	146,559	151,377	157,257	+5,880	+3.9%
Oakland Operations Office..................	34,967	38,290	33,342	-4,948	-12.9%
Total, Oakland Operations Office...............	209,728	224,524	229,235	+4,711	+2.1%
Oak Ridge Operations Office					
Oak Ridge Inst. for Science & Education	189	80	150	+70	+87.5%
Oak Ridge National Laboratory	240	240	240	0	0.0%
Oak Ridge Operations Office	250	214	197	-17	-7.9%
Total, Oak Ridge Operations Office	679	534	587	+53	+9.9%
Richland Operations Office					
Pacific Northwest National Laboratory ..	10	0	0	0	0.0%
Washington Headquarters	10,682	57,705	72,576	+14,871	+25.8%
Subtotal, High Energy Physics..................	680,716	697,743	714,730	+16,987	+2.4%
Use of Prior Year Balances.................	-1,610[a]	0	0	0	0.0%
Total, High Energy Physics.......................	679,106[b]	697,743	714,730[c]	+16,987	+2.4%

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $13,972,000 which has been transferred to the SBIR program and $838,000 which has been transferred to the STTR program.

[c] Includes $5,500,000 for Waste Management activities at Lawrence Berkeley National Laboratory that was previously budgeted in FY 1999 and FY 2000 in the Environmental Management program.

Site Description

Argonne National Laboratory

Argonne National Laboratory in Argonne, Illinois, is a Multiprogram Laboratory located on a 1,700 acre site in suburban Chicago. ANL has a satellite site located in Idaho Falls, Idaho. High Energy Physics supports a program of physics research and technology R&D at ANL, using unique capabilities of the laboratory in the areas of accelerator R&D techniques and participation in the CDF and MINOS detector collaborations.

Brookhaven National Laboratory

Brookhaven National Laboratory is a Multiprogram Laboratory located on a 5,200 acre site in Upton, New York. High Energy Physics supports a program of physics research and technology R&D at BNL, using unique capabilities of the laboratory, including the Accelerator Test Facility and the capability for precision experimental measurement. High Energy Physics also makes limited use of the Alternating Gradient Synchrotron which is principally supported by the Nuclear Physics program.

Fermi National Accelerator Laboratory

Fermi National Accelerator Laboratory is a program-dedicated laboratory (High Energy Physics) located on a 6,800 acre site in Batavia, Illinois. Fermilab operates the Tevatron accelerator and colliding beam facility which consists of a four mile ring of superconducting magnets and is capable of accelerating protons and antiprotons to one TeV. Thus the Tevatron is the highest energy particle accelerator in the world, and has a unique capability for research at the energy frontier. Fermilab, together with SLAC, constitute the principal experimental facilities of the DOE High Energy Physics program.

Lawrence Berkeley National Laboratory

Lawrence Berkeley National Laboratory is a Multiprogram Laboratory located in Berkeley, California. The Lab is on a 200 acre site adjacent to the Berkeley campus of the University of California. High Energy Physics supports a program of physics research and technology R&D at LBNL, using unique capabilities of the laboratory primarily in the areas of participation in the BaBar collaboration, expertise in superconducting magnet R&D, world-forefront expertise in laser driven particle acceleration, and expertise in design of forefront electronic devices.

Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory is a Multiprogram Laboratory located on a 821 acre site in Livermore, California. High Energy Physics supports a program of physics research and technology R&D at LLNL, using unique capabilities of the laboratory primarily in the area of advanced accelerator R&D and participation in the B-factory project.

Los Alamos National Laboratory

Los Alamos National Laboratory is a Multiprogram Laboratory located on a 27,000 acre site in Los Alamos, New Mexico. High Energy Physics supports a program of physics research and technology R&D at LANL, using unique capabilities of the laboratory primarily in the area of theoretical studies, and computational techniques for accelerator design.

Oak Ridge Institute for Science and Education

Oak Ridge Institute for Science and Education is located on a 150 acre site in Oak Ridge, Tennessee. The High Energy Physics program supports a small effort at ORISE in the area of program planning and review.

Oak Ridge National Laboratory

Oak Ridge National Laboratory is a Multiprogram Laboratory located on a 24,000 acre site in Oak Ridge, Tennessee. The High Energy Physics program supports a small research effort using unique capabilities of ORNL primarily in the area of particle beam shielding calculations.

Pacific Northwest National Laboratory

Pacific Northwest National Laboratory is a Multiprogram Laboratory located on 640 acres at the Department’s Hanford site in Richland, Washington. The High Energy Physics program supports a small research effort using unique capabilities of PNNL in the area of low background experiments.

Princeton Plasma Physics Laboratory

Princeton Plasma Physics Laboratory is a program-dedicated laboratory (Fusion Energy Sciences) located on 72 acres in Princeton, New Jersey. The High Energy Physics program supports a small research effort using unique capabilities of PPPL in the area of advanced accelerator R&D.

Stanford Linear Accelerator Center

Stanford Linear Accelerator Center is a program-dedicated laboratory (High Energy Physics) located on 426 acres in Menlo Park, California. SLAC operates for High Energy Physics the newly completed B-factory, the SLAC Linear Collider with the Stanford Large Detector, and a program of fixed target experiments. All of these facilities make use of the two mile long linear accelerator, or linac. SLAC, together with Fermilab, constitute the principal experimental facilities of the DOE High Energy Physics program.

All Other Sites

The High Energy Physics program supports about 230 research groups at 106 colleges and universities located in 36 states, Washington, D.C., and Puerto Rico. The strength and effectiveness of the university-based program is critically important to the success of the program as a whole. These university based components of the HEP program provides access to some of the best scientific talent in the nation.

The High Energy Physics program also funds research at a small number of non DOE laboratories and non-government laboratories and institutes.

Research and Technology

Mission Supporting Goals and Objectives

The High Energy Physics program has two major subprograms. The Research and Technology subprogram provides support for the scientists who perform the research which is the core of the program, and the technology R&D, which is essential to maintain the accelerator and detector facilities at the cutting edge required for a successful research program. The High Energy Physics Facilities subprogram, described later, provides the large facilities – accelerators, detectors, colliding beam devices – needed for the research program.

The Physics Research category in the Research and Technology subprogram provides support for university and laboratory based research groups conducting experimental and theoretical research in high energy physics. This research probes the nature of matter and energy at the most fundamental level, and the characteristics of the basic forces in nature. Experimental research activities include: planning, design, fabrication and installation of experiments; conduct of experiments; analysis and interpretation of data; and publication of results. Theoretical physics research provides the framework for interpreting and understanding observed phenomena and, through predictions and extrapolations based on current understanding, identifies key questions for future experimental explorations. This subprogram supports research groups at more than 100 major universities and at 9 DOE laboratories.

The High Energy Physics Technology category in the Research and Technology subprogram provides the specialized advanced technology R&D required to sustain and extend the technology base and provide operational support for the highly specialized accelerators, colliding beams facilities, and detector facilities which are essential to the overall high energy physics program goal of carrying out forefront research. The objectives of this category include: 1) carrying out R&D in support of existing accelerator and detector facilities aimed at maintaining and improving their performance parameters and cost effectiveness; 2) carrying out R&D support of planned and proposed projects to maximize their performance goals and cost effectiveness; 3) carrying out R&D to transfer new concepts and technologies into practical application in the High Energy Physics context; and 4) carrying out R&D to search for and develop new concepts and ideas that could lead to significant enhancements for research capabilities or to significant cost savings in the construction and operation of new facilities. This category supports work primarily at the DOE labs, but also at universities, other federal labs, and in industry.

Performance Measures

- Quality of scientific results and plans as indicated by expert advisory committees, recognition by the scientific community, and awards received by DOE-supported High Energy Physics researchers. The results of these reviews and other quality measures will be used to determine programmatic directions aimed at maintaining the world leadership position of the U.S. high energy physics program.

- Sustained achievement in advancing knowledge, as measured by the quality of the research based on results published in refereed scientific journals, and by the degree of invited participation at national and international conferences and workshops.
- Review at least 80 percent of the research projects by appropriate peers; continue to select research projects through a merit-based competitive process.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Physics Research	149,207	158,368	156,170	-2,198	-1.4%
High Energy Physics Technology	65,684	70,822	74,331	+3,509	+5.0%
SBIR/STTR	0	0	7,219	+7,219	+100.0%
Total, Research and Technology	214,891	229,190	237,720	+8,530	+3.7%

Detailed Program Justification

(dollars in thousands)

	FY 1999	FY 2000	FY 2001

Physics Research

Physics Research			
Universities	98,556	107,508	105,640
Fermilab	10,658	7,957	7,837
SLAC	12,094	11,635	11,715
BNL	8,198	9,997	9,842
LBNL	11,305	11,126	10,956
ANL	5,712	5,645	5,565
Other Physics Research	2,684	4,500	4,615
Total, Physics Research	149,207	158,368	156,170

- **Universities—**The University Program consists of groups at 102 universities doing experiments (79 universities) and theory (75 universities). These university groups plan, build, execute, analyze and publish results of experiments, train graduate students and post-docs; and provide theoretical concepts, simulations and calculations of physical processes involved in high energy physics. These university based research activities are described in more detail below. The recent HEPAP Subpanel (Gilman), recommended that the level of funding for the university

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
based portion of the program be substantially increased over inflation over the next two year period. Following this recommendation, the overall funding for the university program has been provided with a modest increase above inflation. This modest increase is composed primarily of an increase of $5,500,000 in the capital equipment allocated to the university program in High Energy Physics Facilities offset by the $1,868,000 decrease in operating funds shown below. The combination results in a 3.4% increase.			
▸ **University Research at Fermilab**—Some 56 DOE-funded universities participate in large international collaborations doing experiments at Fermilab. These experiments involve the CDF and D-Zero collider detectors, and the KTEV, FOCUS, MINOS, DONUT, and HYPER-CP experiments using external beams of kaons, photons, neutrinos and hyperons. Other experiments are performed in the antiproton accumulator. The experiments study the production and interaction of quarks and gluons as a probe for new particles such as the Higgs, search for evidence for the possible mass of the neutrino and for the transition of neutrinos among the various types, search for possible sources for the asymmetry of matter over antimatter in the universe, and a number of other topics. These universities help to fabricate the detectors, plan and execute the experiments, analyze data and publish the results. The participation has been and is expected to remain about constant, as activity related to 800 GeV fixed target experiments diminishes and Tevatron, MINOS, and other new experiments related activities increases.	25,705	28,045	27,555
▸ **University Research at SLAC**—Some 27 DOE-funded universities participate in large international collaborations doing experiments at SLAC. The experiments involve the BaBar detector and other smaller detectors for fixed target experiments. These experiments are investigating fundamental constituents of matter such as the b quark. In particular, the BaBar detector is being used to study the nature of CP violation in the B meson system.			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
These universities help to build the detectors, plan and carry out experiments, analyze the data and publish the results. The participation has been and is expected to remain about constant, as SLD diminishes, BaBar flourishes, and work on a future large linear collider continues.	10,420	11,370	11,170
▸ **University Research at BNL**—Some 10 DOE-funded universities participate in collaborative experiments at BNL. These experiments involve fixed targets and kaon or pion beams, colliding beams of protons (RHIC-SPIN) or nuclei (PHOBOS) at RHIC, and an external storage ring measuring the muon anomalous magnetic moment to high precision.	3,145	3,430	3,370
▸ **University Research at Cornell**—Some 11 university High Energy Physics groups with DOE funding participate in the electron-positron colliding beam experiments at Cornell's CESR facility utilizing the collaboratively built CLEO detector studying various aspects of b meson interactions and decay. They help to plan, build, execute, analyze and publish the experiments.	5,220	5,700	5,600
▸ **University Research not at Accelerators**—Some 29 DOE-funded universities are involved in High Energy Physics experiments not utilizing accelerators. These experiments, which are primarily in the areas of astrophysics and cosmology, include MACRO (Italy), Super-Kamiokande (Japan), KamLAND (Japan), SNO (Canada), CHOOZ (France), SOUDAN (Minnesota), CDMS (Stanford), GRANITE (Mt. Hopkins, Arizona), Palo Verde (Arizona) and AMS (Space Station). These university based research groups build the detectors, plan, and execute the experiment, analyze the data and publish the results.	8,050	8,780	8,630
▸ **University Research at Foreign Labs**—Universities funded by the DOE are doing experiments with international collaborations using facilities at foreign accelerator labs. Some 45 universities are conducting experiments at CERN (Switzerland), 11 at DESY (Germany), 10 at KEK (Japan), 1 at IHEP (Russia), 1 at BINP (Russia), and 2 at Beijing (China). This research addresses a wide range of fundamental			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
questions such as the search for the Higgs boson which may be a key to understanding the source of mass. They help to fabricate the detectors and experimental apparatus, plan and execute the experiments, analyze the data and publish the results.	21,805	23,790	23,375
‣ **University Research in Theory**—Some 75 universities with DOE funding participate in research in theoretical high energy physics. This effort is expected to remain about constant. They provide theoretical ideas, concepts, calculations and simulations of physical processes in high energy physics..	21,600	23,565	23,155
‣ **Other University Funding ¾** Primarily includes funding held pending completion of peer review of proposals that have been received, and funds to respond to new and unexpected physics opportunities. The Outstanding Junior Investigator program, that is intended to identify and provide support for highly promising investigators at an early stage in their careers, will continue at a level of about $400,000....	2,611	2,828	2,785
Total, Universities	98,556	107,508	105,640
▪ **Fermilab**—In FY 2001, the experimental physics research groups at Fermilab will be focused mainly on the following activities: data-taking with the upgraded CDF and D-Zero collider detector facilities, analysis of data taken in the 800 GeV fixed-target program, construction of the MINOS detector, construction of the CMS detector for the LHC. The theoretical particle physics and astrophysics groups will be working on a variety of theoretical topics.	10,658	7,957	7,837
▪ **SLAC**—The experimental physics research groups at SLAC will concentrate their efforts in FY 2001 on data-taking and analysis of data from the BaBar detector operating with the PEP-II accelerator facility, as well as completing the analysis of the data from the operation of the SLD detector. Fabrication of the Gamma Large Area Space Telescope (GLAST) will be a significant effort in FY 2001 in preparation for the launch projected to be in FY 2005. GLAST will study the very high energy cosmic rays reaching the earth before they have interacted in the			

	FY 1999	FY 2000	FY 2001
	(dollars in thousands)		
atmosphere. Some physics research will also be done by fixed target experiments. The theoretical physics group will continue to emphasize topics related to BaBar and the other SLAC experimental physics programs as well as tests of the Standard Model and Quantum chromodynamics (QCD).	12,094	11,635	11,715
▪ **BNL**—In FY 2001, the BNL experimental physics research groups will be primarily working on the D-Zero experiment, which will be taking data at Fermilab, and contributing to the fabrication of the ATLAS detector for the LHC. Data collection for the precision measurement of the anomalous magnetic moment of the muon will be completed. An upgraded rare kaon decay experiment at the AGS facility, will begin operation. The theoretical physics group will be working on a number of topics.	8,198	9,997	9,842
▪ **LBNL¾** In FY 2001, LBNL researchers will be focused on a number of research activities, including: data-taking with the CDF collider detector at Fermilab; data-taking with the BaBar detector at the PEP-II storage ring at SLAC; data-analysis on the HYPER-CP experiment will be underway; and fabrication of the ATLAS detector, primarily the silicon tracking system, for the LHC. The researchers will also be working on supernova measurements to establish values of cosmological parameters. Funding is included for the Particle Data Group at LBNL, which continues as an international clearinghouse for particle physics information.	11,305	11,126	10,956
▪ **ANL¾** The experimental high energy physics group will continue collaborating in research on the CDF at Fermilab, and ZEUS at the DESY/HERA facility in Hamburg, Germany. They also will be working on the fabrication of two major new detector facilities: the ATLAS detector for future use at CERN's LHC facility, and the MINOS detector at the Soudan site in Minnesota. The MINOS detector is part of the NuMI project and will use a neutrino beam from Fermilab. The theoretical physics group will continue their research in formal theory, collider phenomenology, and lattice gauge calculations.	5,712	5,645	5,565

	FY 1999	FY 2000	FY 2001
▪ **Other Physics Research¾** LLNL is involved in the BaBar detector, in the MINOS project, as well as non-accelerator experiments. ORNL is carrying out accelerator and beamline shielding studies. LANL is involved in theoretical studies and certain non-accelerator experiments. Includes funds for research activities that have not yet completed their peer review. Funding at $1,800,000 is planned for an expanded R&D effort on the SNAP experiment to clarify the design, feasibility and scientific capability of the proposed instrument to explore dark matter, dark energy and the expanding universe by measuring the velocity of distant supernovae. This category also includes funding of conferences, studies, and workshops	2,684	4,500	4,615
Total, Physics Research	149,207	158,368	156,170

(dollars in thousands)

High Energy Physics Technology

High Energy Physics Technology			
Fermilab	15,900	14,430	15,370
SLAC	19,520	19,595	23,115
BNL	6,290	6,255	5,215
LBNL	10,247	10,518	10,328
ANL	2,150	2,160	2,135
Universities	9,049	11,595	11,965
Other Technology R&D	2,528	6,269	6,203
Total, High Energy Physics Technology	65,684	70,822	74,331

- **Fermilab**
  - Accelerator R&D—Activities in FY 2001 include design of an improved proton source; design of an electron cooling system to improve the quality of an antiproton beam processed through the Recycler ring; R&D in support of the NuMI project; engineering R&D on and construction of quadrupole magnets for the LHC interaction regions; and R&D to lay the technology foundations, long term, for possible future

(dollars in thousands)		
FY 1999	FY 2000	FY 2001

accelerators and experiments. The latter includes continuation of R&D on the NLC begun formally in the first quarter of FY 2000 by a memorandum of understanding between SLAC and Fermilab. Fermilab has assumed the principle R&D responsibility for the two main linac beam lines, including accelerating structures, supports, and instrumentation and control. A major SLAC and Fermilab collaborative R&D activity is application of the Fermilab developed permanent magnet technology throughout the entire NLC beam optics chain. Fermilab is also responsible for applying their expertise in conventional civil construction to issues that could significantly reduce the NLC construction cost. There will also be an expanded accelerator physics effort, in collaboration with SLAC, to more fully understand all aspects of the beam optics and beam transport for the NLC from the electron and positron sources to the electron-positron collision point. Longer range R&D addresses the feasibility and design issues for muon colliders/neutrino sources. A critical test issue is the demonstration of the feasibility of ionization cooling. The muon cooling experiment, for which Fermilab is lead laboratory and LBNL a major collaborator, is part of a national Muon Collider/Neutrino Source Collaboration (including ANL, BNL, Fermilab, LBNL and a number of universities) that is also addressing the second critical issue (at BNL) of an intense Muon target/source and extensive accelerator physics and accelerator and storage ring systems studies. Fermilab is also engaged in an advanced superconducting magnet and materials program (principally niobium tin) to develop magnetic optical elements for use in a muon collider/neutrino source and, in the very far term, a possible 100 TeV proton collider. The general Accelerator R&D activities are increased by about $1,530,000 reflecting the need to support the initial operation of the Tevatron with the new Main Injector/Recycler and the two upgraded detectors, and the need for a more significant effort, as outlined above, to look at long term facility options for Fermilab and for the national program. NLC R&D

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
will decrease by $500,000 to $1,200,000 in FY 2001. The muon collider R&D activities will remain constant in FY 2001.	8,540	8,430	9,460
‣ Experimental Facilities R&D: Activities in FY 2001 include: R&D on pixel silicon detectors and related R&D for a possible dedicated collider detector for studying B meson interactions; R&D on photon veto systems for an experiment searching for rare decays of kaons; R&D on radiation-hard materials such as diamond and silicon carbide to replace silicon micro strip detectors at high collision rates; R&D on specialized electronics for high event rates in numerous, high-density data channels; and developing parallel computing configurations, high speed networks, and high-capacity data storage systems for high data rates.	7,360	6,000	5,910
Total, Fermilab	15,900	14,430	15,370

- **SLAC**
  - Accelerator R&D—Activities in FY 2001 will focus on R&D issues central to the design of the Next Linear Collider (NLC), an electron-positron colliding beam facility to operate in the 500 GeV to 1 TeV center-of-mass energy regime upgradable to 1.5 TeV. The R&D activity at SLAC will focus on design and supporting engineering R&D on the electron and positron sources, damping rings, and connecting beam transport systems. Much of this work is done in collaboration with the Japanese laboratory for HEP, KEK. Technology development for the 11.4 Ghz high powered microwave sources that generate the power to accelerate electrons and positrons will continue with the goal of proving new, more cost effective technical approaches. Some of this R&D will be carried out through contracts placed with industry, exploiting the special “design for manufacture” expertise of industry and accomplishing technology transfer from SLAC to industry. Systems engineering, value engineering and risk analysis studies will be carried out to identify R&D opportunities to lower cost, exploit new technologies, and improve performance. There will be a major collaboration

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
activity with Fermilab to incorporate permanent magnet technology developed for the Fermilab Recycler into the NLC design. Expanded accelerator physics studies will explore the limits of machine performance, look for optimized beam optics and accelerating structure improvements. Some of this work is in collaboration with Fermilab, LBNL and LLNL. An important component of the FY 2001 SLAC program will be accelerator R&D in support of operation of the B-factory. Particular attention will be paid to finding ways to improve the collision luminosity from the design value of $3x10^{33}cm^{-2}s^{-1}$ to greater than $10^{34}cm^{-2}s^{-1}$. A program of general R&D into very advanced collider concepts will continue and will coordinate with the program in advanced accelerator physics that is exploring the potential of lasers, plasmas, and ultra high frequency microwave systems to accelerate charged particles at ultra high gradients. The advanced accelerator R&D will be given slightly increased priority relative to FY 2000. The NLC R&D will be funded at $16,500,000 in FY 2001. (An additional $500,000 is provided to LLNL in this category and $1,000,000 in capital equipment funding for NLC R&D needs is provided under High Energy Physics Facilities subprogram at SLAC).	17,620	17,500	22,050
‣ Experimental Facilities R&D—In FY 2001, the focus will be on instrumentation for physics studies in the center of mass collision energy range of 10 GeV to 5,000 GeV. This will include work to support and improve performance of BaBar, the newly operating B-factory detector, and a modest program of R&D, on developing preliminary designs for a detector to operate with a possible new electron-positron linear collider operating at the TeV center of mass energy scale	1,900	2,095	1,065
Total, SLAC	19,520	19,595	23,115

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
▪ **BNL**			
‣ Accelerator R&D—Activities in FY 2001 will include, R&D on new methods of particle acceleration such as laser acceleration and Inverse Free Electron Laser (IFEL) accelerators, primarily using the excellent capabilities of the BNL Accelerator Test Facility. BNL also has a major involvement in muon collider R&D, primarily in the area of the muon production target and collection systems. This target/capture R&D is critical for demonstrating the feasibility of a muon collider. In the BNL superconductor test facility the characterization of new high critical temperature superconductors as well as their special requirements for high field magnet fabrication should be better understood. R&D in support of AGS operation will continue at a low level, as needed, in relation to the HEP supported operation of the AGS.	5,215	5,180	4,155
‣ Experimental Facilities R&D—In FY 2001, semiconductor drift photo diodes for detection of photons of energies as low as 50 eV will be designed and produced. Development of radiation hardened monolithic electronics for a number of experiments will continue. Development of lead-tungstate crystals with improved light output will continue. Testing of the modules that constitute the ATLAS barrel calorimeters will begin.	1,075	1,075	1,060
Total, BNL	6,290	6,255	5,215
▪ **LBNL**			
‣ Accelerator R&D—LBNL is a major contributor to accelerator and superconducting magnet R&D for advanced accelerator concepts, including the muon collider and the next linear collider. Development of these concepts is needed to advance the energy and luminosity frontiers to better understand the structure of matter. In FY 2001, preparations for muon cooling experiments, needed to confirm the practicality of a muon collider, will begin at Fermilab, using components developed at LBNL. The high-gradient,			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
all-optical, laser-plasma wakefield accelerator at LBNL will begin accelerating electron bunches........	7,577	7,858	7,708
‣ Experimental Facilities R&D—LBNL has an industry forefront capability for designing and producing custom state-of-the-art electronics, such as silicon vertex detectors, integrated circuit (IC) systems, and other components for high-energy particle detectors such as BaBar at the B-factory and the upgrades to CDF and D–Zero for the next, higher luminosity, runs at Fermilab. LBNL is also involved in developing computer programs for experimental data taking and analysis. In FY 2001, work will continue on large area charge-coupled devices and high-resolution imaging systems, plus the production and testing of IC systems..	2,670	2,660	2,620
Total, LBNL...	10,247	10,518	10,328
▪ **ANL**			
‣ Accelerator R&D—R&D will continue on the acceleration of electrons using structures with plasmas or structures made of dielectric materials called wakefield accelerators. Researchers have achieved predicted accelerating gradients at encouraging levels using this new technique. Results are expected in obtaining high accelerating gradients with greatly enhanced beam stability using dielectric structures, and planning is underway for an upgraded experimental capability to generate much higher accelerator gradients using plasmas in structures driven by intense bunches of electrons. Related theoretical work will also continue...........................	1,230	1,240	1,225
‣ Experimental Facilities R&D—In FY 2001 work will be underway on the MINOS detector, the ATLAS detector for the LHC, and a possible upgrade of the ZEUS detector at DESY.	920	920	910
Total, ANL..	2,150	2,160	2,135

▪ **Universities¾** The funding will provide for a program of high priority technology R&D at about 35 universities relevant to the development of particle accelerators. The R&D is aimed at breakthrough technologies;

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
superconductors for high-field magnets; laser and collective-effect accelerator techniques; novel, high-power radio frequency generators; muon colliders; theoretical studies in particle beam physics, including the non-linear dynamics of particle beams; and at lowering the cost and improving the performance of future experiments and facilities..	9,049	11,595	11,965
▪ **Other Technology R&D—**The funding will provide for a program of high priority technology R&D at a number of other federal laboratories and industrial sites relevant to the development of particle accelerators. The R&D is aimed at breakthrough technologies; superconductors for high-field magnets; laser and collective-effect accelerator techniques; novel, high-power radio frequency generators; theoretical studies in particle beam physics, including the non-linear dynamics of particle beams; and at lowering the cost and improving the performance of future experiments and facilities. Also includes the portion of the funding for R&D on future facility concepts that has not yet been allocated pending program office discussions and peer reviews that are underway.	2,528	6,269	6,203
Total, High Energy Physics Technology...............................	65,684	70,822	74,331
▪ **SBIR/STTR—** Includes $6,370,000 for SBIR, and $849,000 for STTR in FY 2001. Additional funding for the SBIR program is contained in the High Energy Physics Facilities subprogram...	0	0	7,219
Total, Research and Technology..	214,891	229,190	237,720

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
▪ **Physics Research**	
‣ Operating expenses for the University Physics Research program decrease $1,868,000. This is more than offset by the $5,500,000 increase in capital equipment allocated for universities under the High Energy Physics Facilities subprogram.	-1,868
‣ At Fermilab, a decrease of $120,000 in research activities.	-120
‣ At SLAC, an increase of $80,000 related to the increased level of activity resulting from initial operation of the B-factory.	+80
‣ Research decreases at BNL (-$155,000), LBNL (-$170,000), and ANL (-$80,000).	-405
‣ An increase in the funding is unallocated pending the completion of peer reviews and programmatic consideration.	+115
Total, Physics Research	-2,198
▪ **High Energy Physics Technology**	
‣ At Fermilab, an increase in the general Accelerator R&D of $1,530,000 to support work needed to fully integrate and utilize the capability provided by the new Main Injector; offset by decreases of $500,000 in next linear collider R&D and of $90,000 in Experimental Facilities R&D. Muon Collider R&D is held constant	+940
‣ At SLAC, an increase in general Accelerator R&D of $2,250,000 to support work needed to increase the luminosity of the B-factory. It is expected that the luminosity can be increased by a factor of three above the design value. There is also an increase in next linear collider R&D of $2,300,000 to allow this work to proceed on the planned schedule. These increases are partially offset by a decrease in Experimental Facilities R&D of $1,030,000 resulting from the completion of the BaBar detector.	+3,520
‣ At BNL, a decrease in general Accelerator R&D of $1,025,000 reflecting partial completion of a program to enhance the R&D capabilities of the lab, and other reductions in Accelerator R&D and Experimental Facilities R&D.	-1,040
‣ Modest decreases at LBNL ($190,000) and ANL ($25,000).	-215
‣ The University Technology R&D program increases $370,000. This provides an increase of about 3% for the university based Technology R&D program.	+370
‣ In Other Technology R&D, there is a small decrease in other activities.	-66
Total, High Energy Physics Technology	+3,509

	FY 2001 vs. FY 2000 ($000)
▪ **SBIR/STTR**	
‣ An increase of $7,219,000 in the SBIR and STTR allocation. In FY 2000, the SBIR/STTR allocations were all in the High Energy Physics Facilities subprogram.	+7,219
Total Funding Change, Research and Technology	+8,530

The following table summarizes the above changes for R&D on possible future HEP facilities:

	(dollars in millions)		
	FY 1999	FY 2000	FY 2001
Next Linear Collider	17.0	17.4	19.2
Muon-Muon Collider	5.5	8.7	8.7

High Energy Physics Facilities

Mission Supporting Goals and Objectives

The High Energy Physics Facilities subprogram includes the provision and operation of the large accelerator and detector facilities, the essential tools that enable scientists in university and laboratory based research groups to perform experimental research in high energy physics. This subprogram includes funding for the operation and maintenance of the national laboratory research facilities including accelerators, colliders, secondary beam lines, detector facilities for experiments, experimental areas, computing, and computing networking facilities. It includes the costs of detector and accelerator components, personnel, electric power, expendable supplies, replacement parts and subsystems, inventories and waste management activities at Fermilab and SLAC and at LBNL beginning in FY 2001. General Plant Projects (GPP) funding is provided for minor new construction, other capital alterations and additions and for buildings and utility systems. Landlord General Purpose Equipment (GPE), and GPP funding for Brookhaven National Laboratory in FY 1999 and for Lawrence Berkeley National Laboratory in FY 2000 and FY 2001; Fermi National Accelerator Laboratory and Stanford Linear Accelerator Center are also included. Accelerator Improvement Project (AIP) funding support for additions and modifications to accelerator facilities that are supported by the High Energy Physics research program is also included.

The principal objective of the High Energy Physics Facilities subprogram is to maximize the quantity and quality of data collected for approved experiments being conducted at the High Energy Physics facilities. The ultimate measure for success in the High Energy Physics Facilities subprogram is whether the research scientists have data of sufficient quantity and quality to do their planned measurements or to discover new phenomena. The quality of the data is dependent on the accelerator and detector capabilities, and on the degree to which those capabilities are achieved during a particular operating period. The quantity of the data relates primarily to the beam intensity, the length of the operating periods, and the operational availability of the accelerator and detector facilities.

Performance Measures

- Progress on achieving luminosity and operational efficiency for the B-factory at SLAC as measured by comparison with stated project goals.
- Progress on achieving luminosity and operational efficiency for the Tevatron at Fermilab in its new mode of operation with the recently completed Main Injector.
- The upgrade of scientific facilities will be managed to keep them on schedule and within cost.
- In FY 2001, High Energy Physics will be operating the B-factory at SLAC, the Main Injector for the Tevatron at Fermilab, and the AGS at BNL, and will deliver on the scheduled U.S./DOE commitments to the international Large Hadron Collider project.
- Meet on time and within budget the scheduled U.S. DOE commitments to the international Large Hadron Collider project as reflected in the latest international agreement and corresponding plan.

Planned Accelerator Operations

	(in weeks)		
	FY 1999	FY 2000	FY 2001
Fermilab	38	29	22
SLAC	42	39	36
BNL	14	15	17

Funding Schedule

	(dollars in thousands)				
	FY 1999	FY 2000	FY 2001	$ Change	% Change
Fermi National Accelerator Lab	209,937	212,936	207,031	-5,905	-2.8%
Stanford Linear Accelerator Center	112,330	115,447	114,527	-920	-0.8%
Brookhaven National Laboratory	42,375	4,909	7,519	+2,610	+53.2%
Other Facility Support	10,273	16,982	27,338	+10,356	+61.0%
Large Hadron Collider	65,000	70,000	70,000	0	0.0%
Waste Management	4,910	4,910	10,410	+5,500	+112.0%
SBIR/STTR	0[a]	14,669	7,785	-6,884	-46.9%
Total, High Energy Physics Facilities	444,825	439,853	444,610	+4,757	+1.1%

Detailed Program Justification

(dollars in thousands)		
FY 1999	FY 2000	FY 2001

Fermilab

Provides support for operation, maintenance, improvement, and enhancement of the Tevatron accelerator and detector complex. This complex includes the Tevatron, that can operate in a collider mode with protons and anti-protons, or in a fixed target mode with protons only; the new Main Injector that will be completed and commissioned in FY 1999; the Booster; the Linac; and the Anti-proton Source and Accumulator. The Tevatron collider and the 800 GeV fixed target modes are mutually exclusive; however, a fixed target program at 120 GeV using the new Main Injector is possible in parallel with Tevatron collider operation. This complex also includes the two large colliding beams

[a] Excludes $13,972,000 which has been transferred to the SBIR program and $838,000 which has been transferred to the STTR program.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
Detectors – CDF and D-Zero – and a number of fixed target experiments in the external beams areas.			
▪ **Operations**—Operation at Fermilab will include operation of the Tevatron in collider mode for about 22 weeks. This will be a major physics run with the higher intensity available from the new Main Injector and with the newly upgraded D-Zero and CDF detectors....................	167,129	175,507	172,773

Tevatron Operation

	(in weeks)		
	FY 1999	FY 2000	FY 2001
Fixed Target	22	6	0
Collider	0	15	22
Commissioning	16	8	0
Total, Tevatron Operation	38	29	22

	FY 1999	FY 2000	FY 2001
▪ **Support and Infrastructure**— Capital equipment funding for the CDF and D-Zero Upgrade projects is significantly reduced (to $500,000 each) reflecting the planned completion of these two projects in FY 2001. Capital equipment for the MINOS detector is increased to $7,000,000. AIP is funded at $4,300,000 and GPP is funded at $4,800,000.	42,808	37,429	34,258
Total, Fermilab	209,937	212,936	207,031

SLAC

Provides for the operation, maintenance, improvement and enhancement of the accelerator and detector complex on the SLAC site. The accelerators include the electron linac, the NLC Test Accelerator and the B-factory completed in FY 1999. The detector facilities include BaBar, the detector for the B-factory, the End Station A experimental set-ups, and the Final Focus Test Beam. Also provides for maintenance of the laboratory physical plant.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
▪ **Operations**—Operations at SLAC in FY 2001 will concentrate heavily on about 36 weeks of strong utilization of the newly completed asymmetric B-factory colliding beam storage rings to maximize the data collected by the BaBar detector facility. This will be supplemented by a modest (8 weeks) fixed target research program in End Station A. The linac will serve as the injector of positrons and electrons to the B-factory storage rings during this time. This will be the priority research program at SLAC in FY 2001	92,795	95,147	95,447

SLAC Operation

	(in weeks)		
	FY 1999	FY 2000	FY 2001
Fixed Target	10	15[a]	8[k]
B-factory Commissioning	16	0	0
B-factory Operation	16	39	36
Total, SLAC Operation	42	39	36

▪ **Support and Infrastructure**—Includes funding for capital equipment, AIP and GPP needs. Capital equipment funding for GLAST, a MIE with a preliminary TEC of $28,000,000, is included at $3,300,000. Additional capital equipment funding for GLAST in the amount of $1,300,000 is included in the Other Facility Support activity detailed later. Capital equipment for NLC R&D is included at $1,000,000.	19,535	20,300	19,080
Total, SLAC	112,330	115,447	114,527

BNL

Provides support for the HEP related operation, maintenance, improvement, and enhancement of the AGS complex at BNL and its complement of experimental set ups. The AGS was transferred to the Nuclear Physics program during the 3rd

[a] Fixed Target operation in parallel with B-factory operation.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
quarter of FY 1999 to be supported and operated as part of the RHIC facility. In FY 2000 and beyond operation of the AGS for the HEP program is on an incremental cost basis.			
▪ **Operations**—Operation activities covered under this budget category include the incremental cost of running the AGS complex for HEP. Operation for High Energy Physics in FY 2001 will be for about 17 weeks to complete the muon magnetic moment experiment and for initial operation of the upgraded rare kaon decay experiment. The large decrease from FY 1999 to FY 2000 reflects the transfer of the AGS from HEP to NP ..	33,938	3,490	5,920

AGS Operation

	(in weeks)		
	FY 1999	FY 2000	FY 2001
AGS Operation for HEP..	14	15	17

▪ **Support and Infrastructure**—Includes capital equipment funding for the BNL HEP program. Included in FY 1999 only, landlord GPP and GPE funding.	8,437	1,419	1,599
Total, BNL...	42,375	4,909	7,519

Other Facility Support

- Includes $5,000,000 for the establishment of an enhanced capability for large scale computer modeling and simulation. The initial application will be to detail orbit calculations in accelerator magnet rings, and in the large scale numerical calculations of fundamental interactions such as those in quark-gluon collisions.

  Includes $1,950,000 for General Purpose Equipment and $3,500,000 for General Plant Projects at LBNL for landlord related activities.

  Includes capital equipment funding at ANL, LBNL, and some smaller DOE labs. Includes funding for a number of small activities including computer networking. Includes $5,500,000 in capital equipment funding for the

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
University physics research program. These funds will be used primarily for the non-accelerator projects summarized below.	10,273	16,982	27,338

- The Cryogenic Dark Matter Search (CDMS) detector will use cryogenic techniques to search for weakly interacting massive particles (WIMPS). WIMPS are proposed as a possible explanation for the "missing" mass in the universe. CDMS is being done by a collaboration of universities and laboratories. The detector will be installed in the Soudan II underground laboratory in northern Minnesota. The TEC for CDMS is $8,600,000.
- The Kamioka Liquid Scintillator Anti-Neutrino Detector (KamLAND), the largest low-energy antineutrino detector ever built, will be located in the Kamiokande mine in Japan. This detector will attempt to detect whether neutrinos have mass by searching for neutrino oscillations by studying the flux and energy spectra of neutrinos produced by Japanese commercial nuclear reactors. KamLAND is being done in collaboration with a number of Japanese groups. KamLAND is still undergoing program office review. The projected TEC for KamLAND is $3,000,000 to be provided by the HEP and NP programs.
- The Pierre Auger Project (Auger) is intended to detect and study very high energy cosmic rays using a very large array of surface detectors spread over 30,000 square kilometers. Auger is being done by a large international collaboration. The presently approved part of the project includes an array at a site in Argentina. The U.S. will provide only a modest portion of the cost of the Argentine array. The TEC for the U.S. portion of this phase of Auger is $3,000,000.
- The Very Energetic Radiation Imaging Telescope Array System (Veritas) will be a ground based high energy cosmic gamma ray detector designed to search for and study astrophysical gamma ray sources. As such, it will complement GLAST. The Veritas

	(dollars in thousands)	
FY 1999	FY 2000	FY 2001

collaboration includes both U.S. and foreign groups, and will be built at a site in Arizona. The TEC for the U.S. portion of Veritas is $6,000,000.

- The AntiMatter in Space (AMS) experiment was designed to detect antimatter and was operated on a space shuttle flight. The experiment performed well and the data are being analyzed. It is planned to upgrade the detector for a second shuttle flight. The TEC for the DOE portion of the AMS upgrade is $3,000,000.

Large Hadron Collider

In FY 1999 and FY 2000, funding was used for: R&D and measurement/testing on superconducting materials, cable, and wire; calculations and R&D on accelerator physics issues regarding the design, instrumentation, and prototypes of the magnets for the colliding beam intersection regions and RF accelerating regions. Activities on the detectors will include R&D and prototype development of subsystems such as tracking chambers, calorimeters, and data acquisition electronics.

The LHC work is being performed at various locations including 4 major DOE labs and more than 55 U.S. universities.

LHC Accelerator and Detector Funding Summary

(dollars in thousands)	FY 1999	FY 2000	FY 2001
High Energy Physics Facilities			
LHC			
Accelerator Systems			
Operating Expenses	1,205	740	2,200
Capital Equipment	14,195	19,360	15,600
Total, Accelerator Systems	15,400	20,100	17,800
Procurement from Industry	8,091	13,106	18,503
ATLAS Detector			
Operating Expenses	4,792	5,570	5,738
Capital Equipment	4,207	10,924	10,769
Total, ATLAS Detector	8,999	16,494	16,507
CMS Detector			
Operating Expenses	13,472	9,100	8,480
Capital Equipment	19,038	11,200	8,710
Total, CMS Detector	32,510	20,300	17,190
Total, LHC	65,000	70,000	70,000

(dollars in thousands)	FY 1999	FY 2000	FY 2001
▪ **Accelerator Systems**—In FY 2001, funding will support continued production of interaction region quadrupole magnets, dipole magnets, feedboxes, and absorbers; production of radio-frequency region dipole magnets; and completion of fabrication of the superconducting cable for these magnets. Production testing of wire and cable for the LHC main magnets and accelerator physics calculations will continue.	15,400	20,100	17,800
▪ **Procurement from Industry**—In FY 2001, funding will continue to support reimbursement to CERN for purchases from U.S. industry including superconducting wire, cable, and cable insulation materials.	8,091	13,106	18,503
▪ **ATLAS Detector**—In FY 2001, funding will support production of detector hardware and electronics. The barrel cryostat procurement for the liquid argon			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
calorimeter will be completed and procurement and testing will continue for the silicon strip electronics, and the transition radiation tracker electronics. Fabrication efforts will continue for the silicon strip modules, the forward calorimeter, the extended barrel tile calorimeter modules and submodules, the endcap monitored drift tubes, and the cathode strip chambers. Fabrication will be completed for the liquid argon calorimeter feed-throughs and motherboards and installation will begin.	8,999	16,494	16,507
▪ **CMS Detector**—In FY 2001, funding will support full rate production and testing of endcap muon system chambers and the procurement of the electronics and cables for the muon system. The hadron calorimeter barrel will be completed and delivered to CERN and the scintillator and brass absorber assembly will continue along with the testing of the associated electronics. The trigger designs will be completed and testing of the electronics will continue. The data acquisition system will complete prototyping efforts and continue test beam studies. The forward pixel system will complete advanced testing and prepare for production of readout chips and sensors.	32,510	20,300	17,190
Total, Large Hadron Collider	65,000	70,000	70,000
▪ **Waste Management ¾** Provides funding for packaging, shipment and disposition of hazardous, radioactive or mixed waste generated in the course of normal operations at Fermilab, SLAC, and beginning in FY 2001, LBNL. The laboratories continue to explore opportunities to reduce the volume of newly generated waste and its associated management and disposal costs.	4,910	4,910	10,410
▪ **SBIR/STTR ¾** In FY 1999, $13,972,000 was transferred to the SBIR program and $838,000 was transferred to the STTR program. Includes $13,839,000 for the SBIR program and $830,000 for the STTR program in FY 2000			

	FY 1999	FY 2000	FY 2001
and $7,785,000 for SBIR in FY 2001. The balance of the SBIR and STTR allocations for FY 2001 are included in the Research and Technology subprogram.	0	14,669	7,785
Total, High Energy Physics Facilities	444,825	439,853	444,610

(dollars in thousands)

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
▪ **Fermilab**	
‣ At Fermilab, a reduction of $2,734,000 in Operations resulting in a 7 week reduction in the projected running schedule as the upgraded CDF and D-Zero detectors are completed.	-2,734
‣ At Fermilab, increases of $1,132,000 in capital equipment funding for the MINOS detector and $4,931,000 in other capital equipment funding are offset by reductions of $4,879,000 in capital equipment funding for the CDF Upgrade, and $4,355,000 in capital equipment funding for the D-Zero Upgrade. The increase in other capital equipment is needed for anticipated hardware needs to correct problems appearing during the final commissioning of the Tevatron and Main Injector and to begin to meet second priority capital equipment needs in the laboratory that were deferred in previous years to make funding available for the large detectors.	-3,171
Total, Fermilab	-5,905
▪ **Stanford Linear Accelerator Center**	
‣ At SLAC, an increase of $300,000 in Operations. This only partly offsets the impact of inflation resulting in a decrease of 3 weeks in the projected running schedule..	+300
‣ At SLAC, the reduction of $1,220,000 in Support and Infrastructure is primarily a reduction in capital equipment funding reflecting an anticipated reduction in the need for new ancillary accelerator equipment since the B-factory is a new machine.	-1,220
Total, Stanford Linear Accelerator Center	-920

	FY 2001 vs. FY 2000 ($000)
▪ **Brookhaven National Laboratory**	
‣ At BNL, an increase of $2,430,000 to support AGS operation to complete the muon magnetic moment experiment and the initial testing of the rare kaon decay experiment in advance of full operation in FY 2002.	+2,430
‣ At BNL, an increase of $180,000 in capital equipment funding to support the planned upgrade of the rare kaon decay experiment.	+180
Total, Brookhaven National Laboratory	+2,610
▪ **Other Facility Support**	
‣ Decreases in capital equipment funding at ANL ($15,000) and LBNL ($45,000).	-60
‣ An increase in capital equipment funding provides funds primarily for fabrication of five non-accelerator major items of equipment assigned to the university based Physics Research program.	+5,500
‣ An increase of $5,000,000 to provide for the establishment of an enhanced capability for large scale computational modeling and simulation.	+5,000
‣ A reduction of $84,000 in the funds held in reserve pending completion of peer review and programmatic consideration.	-84
Total, Other Facility Support	+10,356
▪ **Waste Management**	
‣ In Waste Management, an increase of $5,500,000 reflecting the transfer of Waste Management responsibility at LBNL to the HEP budget from Environmental Management in FY 2001.	+5,500
▪ **SBIR/STTR**	
‣ A reduction of $6,884,000 in funding for SBIR and STTR reflecting the transfer of about half of the SBIR/STTR funding to the Research and Technology subprogram. The combined overall change in SBIR/STTR is $335,000.	-6,884
Total Funding Change, High Energy Physics Facilities	+4,757

Construction

Mission Supporting Goals and Objectives

This provides for the construction of major new facilities needed to meet the overall objectives of the High Energy Physics Program.

Performance Measures

- Make progress on the Neutrinos at the Main Injector project as measured by accomplishment of scheduled milestones as detailed in the benchmark plan.

Funding Schedule

	(dollars in thousands)				
	FY 1999	FY 2000	FY 2001	$ Change	% Change
Construction	21,000	28,700	32,400	+3,700	+12.9%

Detailed Program Justification

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
Neutrinos at the Main Injector (NuMI)¾ This project provides for the construction of new facilities at Fermilab and at the Soudan Underground Laboratory in Soudan, Minnesota that are specially designed for the study of the properties of the neutrino and in particular to search for neutrino oscillations. The FY 2001 funding is for construction of the neutrino production target, neutrino focusing horns, beam tunnel, underground detector and detector halls, and surface buildings at Fermilab.	14,300	22,000	23,000
Wilson Hall Safety Improvement Project (Fermilab)—This project provides for urgently needed rehabilitation of the main structural elements of Wilson Hall, and for urgently needed rehabilitation of windows, plumbing, the roof and the exterior of the building.	6,700	4,700	4,200

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
SLAC Research Office Building—This project provides urgently needed office space for the substantial expansion of visiting scientists, or "users", resulting from the B-factory becoming operational. The visiting user population is projected to increase from 200 visitors per year to 1,100 visitors per year. The new building will provide about 30,000 square feet and will be completed in FY 2001	0	2,000	5,200
Total, Construction	21,000	28,700	32,400

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
▪ Continuation of the Fermilab NuMI project on the planned profile.	+1,000
▪ Provides for completion of the Wilson Hall Safety Improvement Project at Fermilab on the planned profile	-500
▪ Provides for completion of the Research Office Building on the planned profile.	+3,200
Total Funding Change, Construction	+3,700

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
General Plant Projects	15,185	12,500	12,500	0	0.0%
Accelerator Improvements Projects........	7,231	8,900	8,880	-20	-0.2%
Capital Equipment................................	92,315	89,167	84,329	-4,838	-5.4%
Total, Capital Operating Expense..........	114,731	110,567	105,709	-4,858	-4.4%

Construction Projects

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp-riations	FY 1999	FY 2000	FY 2001	Unapprop-riated Balance
98-G-304 Neutrinos at the Main Injector	76,200	5,500	14,300	22,000	23,000	11,400
99-G-306 Wilson Hall Safety Improvements......................................	15,600	0	6,700	4,700	4,200	0
00-G-307 SLAC Research Office Building..	7,200	0	0	2,000	5,200	0
Total, Construction...............................		5,500	21,000	28,700	32,400	11,400

Major Items of Equipment *(TEC $2 million or greater)*

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp-riations	FY 1999	FY 2000	FY 2001	Accept-ance Date
D-Zero Upgrade....................	57,902	44,092	8,455	4,855	500	FY 2001
CDF Upgrade	56,916	41,482	9,555	5,379	500	FY 2001
B-factory Detector (BaBar) [a]...	68,000	64,200	3,800	0	0	FY 1999
Large Hadron Collider — Machine	87,340	11,785	14,195	19,360	15,600	FY 2005
Large Hadron Collider — ATLAS Detector....................	56,416	6,198	4,207	10,924	10,769	FY 2005
Large Hadron Collider — CMS Detector........................	70,125	5,517	19,038	11,200	8,710	FY 2005
MINOS.................................	45,709	0	2,600	5,868	7,000	FY 2004
GLAST [b]..............................	28,000	0	0	3,000	4,600	FY 2005
Cryogenic Dark Matter Search (CDMS)	8,600	0	0	0[c]	1,750	FY 2007
KamLAND [d]..........................	3,000	0	0	0[n]	800	FY 2002
Auger..................................	3,000	0	0	0[n]	1,250	FY 2003
Veritas [e]	6,000	0	0	0[n]	1,500	FY 2005
Antimatter in Space (AMS) Upgrade	3,000	0	0	0[n]	1,000	FY 2003
Total, Major Items of Equipment............................		173,274	61,850	60,586	53,979	

[a] The funding for the B-factory detector reflects cost savings of about $20,000,000 resulting from contributions of components and subsystems by non-U.S. collaborating institutions.

[b] Total estimated cost is subject to further negotiations with NASA and potential foreign collaborators.

[c] These major items of equipment were recently reviewed and recommended for initiation in FY 2000. HEP currently plans to support these major items of equipment that were approved after the FY 2000 budget was submitted to Congress.

[d] Funding split equally between High Energy Physics and Nuclear Physics budgets. KamLAND is only being shown on High Energy Physics table to display total TEC of $3,000,000.

[e] Approval still pending Program Office peer-review.

98-G-304, Neutrinos at the Main Injector (NuMI), Fermi National Accelerator Laboratory, Batavia, Illinois

(Changes from FY 2000 Congressional Budget Request are denoted with a vertical line [|] in the left margin.)

Significant Changes

Total Project Cost and the Completion Date have been adjusted due to changes in the MINOS detector profile.

1. Construction Schedule History

	Fiscal Quarter				Total Estimated Cost ($000)	Total Project Cost ($000)
	A-E Work Initiated	A-E Work Completed	Physical Construction Start	Physical Construction Complete		
FY 1998 Budget Request *(A-E and technical design only)*.........................	1Q ’98	4Q ‘98	NA	NA	5,500	6,300
FY 1999 Budget Request (Preliminary Estimate)..	--	3Q ‘99	1Q ‘99	4Q ‘02	75,800	135,300
FY 2000 Budget Request	3Q ‘98	2Q ‘00	3Q ‘99	2Q ‘03	76,200	136,100
FY 2001 Budget Request	3Q ‘98	2Q ‘00	3Q ‘99	2Q ‘04	76,200	138,600

2. Financial Schedule

(dollars in thousands)

Fiscal Year	Appropriations	Obligations	Costs
Design & Construction			
1998	5,500	5,500	1,140
1999	14,300	14,300	5,846
2000	22,000	22,000	26,300
2001	23,000	23,000	27,000
2002	11,400	11,400	11,900
2003	0	0	4,014

3. Project Description, Justification and Scope

The project provides for the design, engineering and construction of new experimental facilities at Fermi National Accelerator Laboratory in Batavia, Illinois and at the Soudan Underground Laboratory at Soudan, Minnesota. The project is called NuMI which stands for Neutrinos at the Main Injector. The purpose of the project is to provide facilities that will be used by particle physicists to study the properties of neutrinos, which are fundamental elementary particles. In the Standard Model of elementary particle physics there are three types of neutrinos that are postulated to be massless and to date, no direct experimental observation of neutrino mass has been made. However, there are compelling hints from experiments that study neutrinos produced in the sun and in the earth's atmosphere that indicate that if neutrinos were capable of changing their type it could provide a credible explanation for observed neutrino deficits in these experiments.

The primary element of the project is a high flux beam of neutrinos in the energy range of 1 to 40 GeV. The technical components required to produce such a beam will be located on the southwest side of the Fermilab site, tangent to the new Main Injector accelerator at the MI-60 extraction region. The beam components will be installed in a tunnel of approximately 1 km in length and 6.5 m diameter. The beam is aimed at two detectors (MINOS) which will be constructed in experimental halls located along the trajectory of the neutrino beam. One such detector will be located on the Fermilab site, while a second will be located in the Soudan Underground Laboratory. Two similar detectors in the same neutrino beam and separated by a large distance are an essential feature of the experimental plan.

The experiments that are being designed to use these facilities will be able to search for neutrino oscillations occurring in an accelerator produced neutrino beam and hence determine if neutrinos do have mass. Fermilab is the only operational high energy physics facility in the U.S. with sufficiently high energy to produce neutrinos which have enough energy to produce tau leptons. This gives Fermilab the unique opportunity to search for neutrino oscillations occurring between the muon and the tau neutrino. Additionally, the NuMI facility is designed to accommodate future enhancements to the physics program that could push the search for neutrino mass well beyond the initial goals established for this project.

4. Details of Cost Estimate [a]

	(dollars in thousands)	
	Current Estimate	Previous Estimate
Design Phase		
Preliminary and Final Design costs	7,150	7,150
Design Management costs (0.0% of TEC)	10	10
Project Management costs (0.0% of TEC)	20	20
Total, Engineering design inspection and administration of construction costs (9.4% of TEC)	7,180	7,180
Construction Phase		
Buildings	8,320	8,320
Special Equipment	10,120	10,120
Other Structures	30,960	30,960
Construction Management (6.0% of TEC)	4,590	4,590
Project Management (2.8% of TEC)	2,170	2,170
Total, Construction Costs	56,160	56,160
Contingencies		
Design Phase (2.8% of TEC)	2,172	2,172
Construction Phase (14.0% of TEC)	10,688	10,688
Total, Contingencies (16.8% of TEC)	12,860	12,860
Total, Line Item Cost (TEC)	76,200	76,200

5. Method of Performance

Design of the facilities will be by the operating contractor and subcontractor as appropriate. To the extent feasible, construction and procurement will be accomplished by fixed-price contracts awarded on the basis of competitive bids.

[a] The annual escalation rates assumed for FY 1996 through FY 2002 are 2.5, 2.8, 3.0, 3.1, 3.3, 3.4, and 3.4 percent respectively.

6. Schedule of Project Funding

	(dollars in thousands)					
	Prior Years	FY 1999	FY 2000	FY 2001	Outyears	Total
Project Cost						
Facility Cost						
Total, Line item TEC............................	1,140	5,846	26,300	27,000	15,914	76,200
Other Project Costs						
Capital equipment [a].............................	0	2,560	5,868	7,000	30,281	45,709
R&D necessary to complete construction [b]	1,260	40	0	0	0	1,300
Conceptual design cost [c]......................	830	0	0	0	0	830
Other project-related costs [d]..................	1,520	1,960	5,632	3,382	2,067	14,561
Total, Other Project Costs..........................	3,610	4,560	11,500	10,382	32,348	62,400
Total Project Cost (TPC)............................	4,750	10,406	37,800	37,382	48,262	138,600

[a] Costs to fabricate the near detector at Fermilab and the far detector at Soudan. Includes systems and structures for both near detector and far detector, active detector elements, electronics, data acquisition, and passive detector material.

[b] This provides for project conceptual design activities, for design and development of new components, and for the fabrication and testing of prototypes. R&D on all elements of the project to optimize performance and minimize costs will continue through early stages of the project. Specifically included are development of active detectors and engineering design of the passive detector material. Both small and large scale prototypes will be fabricated and tested using R&D operating funds.

[c] Includes operating costs for development of conceptual design and scope definition for the NuMI facility. Also includes costs for NEPA documentation, to develop an Environmental Assessment, including field tests and measurements at the proposed construction location.

[d] Include funding required to complete the construction and outfitting of the Soudan Laboratory for the new far detector by the University of Minnesota.

7. Related Annual Funding Requirements

	(FY 2003 dollars in thousands)	
	Current Estimate	Previous Estimate
Annual facility operating costs [a]	500	500
Utility costs (estimate based on FY 1997 rate structure) [b]	500	500
Total related annual funding	1,000	1,000
Total operating costs *(operating from FY 2003 through FY 2007)*	5,000	5,000

[a] Including personnel and M&S costs (exclusive of utility costs), for operation, maintenance, and repair of the NuMI facility.

[b] Including incremental power costs for delivering 120 GeV protons to the NuMI facility during Tevatron collider operations, and utility costs for operation of the NuMI facilities, which will begin beyond FY 2002.

99-G-306, Wilson Hall Safety Improvements Project, Fermi National Accelerator Laboratory, Batavia, Illinois

(Changes from FY 2000 Congressional Budget Request are denoted with a vertical line [|] in the left margin.)

1. Construction Schedule History

	Fiscal Quarter				Total Estimated Cost ($000)	Total Project Cost ($000)
	A-E Work Initiated	A-E Work Completed	Physical Construction Start	Physical Construction Complete		
FY 1999 Budget Request	1Q '99	2Q '00	3Q '99	3Q '02	15,600	18,800
FY 2000 Budget Request	1Q '99	2Q '00	3Q '99	3Q '02	15,600	18,800
FY 2001 Budget Request	1Q '99	2Q '00	3Q '99	3Q '02	15,600	18,800

2. Financial Schedule

(dollars in thousands)

Fiscal Year	Appropriations	Obligations	Costs
Construction			
1999	6,700	6,700	674
2000	4,700	4,700	6,340
2001	4,200	4,200	6,990
2002	0	0	1,596

3. Project Description, Justification and Scope

Wilson Hall, constructed in 1972, is the central laboratory facility for the Fermilab site. It is a 17 story reinforced concrete building with a 16 story atrium. The great majority of its area is devoted to office space. In addition, the building contains the cafeteria, the communications center, medical office, some light industrial and shop areas, and an 800 seat auditorium.

The Wilson Hall Safety Improvements Project is a comprehensive project to remediate the deficiencies in this facility. Among the causes for the deficiencies are the age of the building and its systems, safety issues and updating to current code standards, and building components and systems that have reached their useful life expectancy.

The structural deficiencies are currently resulting in the ongoing safety issue of falling concrete debris in occupied areas of the building, and will eventually threaten the integrity of the entire facility. Additional spalling of the concrete could occur on the exterior faces of the building. The current glazing in the sloped window walls is not the code required safety glass. Breakage could result in the falling of sharp edged shards of glass into the atrium area. The quality of the existing drinking water is poor (taste & color) resulting in low usage which allows levels of lead and copper to exceed regulatory requirements.

The building structure portion of this project provides for the rehabilitation of the existing concrete structure at the crossover bays, which connect the two towers that comprise Wilson Hall. The joints between the crossover bays and tower are experiencing significant structural degradation, resulting in the ongoing safety issue of falling debris and the probability of continued deterioration of the joints. Recent computer analysis of the movement of the building structure has indicated that the joints need to be reworked to allow for the seasonal movement caused by temperature changes. This project will implement the solution to the joint erosion problem. It will consist of reconstructing the joints (assuring effective independent movement of each tower). Since a number of areas in the building will have restricted occupancy while the repairs are being made, this project will include the staff relocation required to accommodate the construction as part of Other Project Costs. At the completion of the structural joint repairs, a thorough exterior inspection will be conducted and any necessary repairs completed.

The building envelope portion of this project provides for the weatherproofing of components of the building shell that are currently allowing water penetration, the refurbishment of the existing skylight system, refinishing and partially reglazing the north and south curtain walls, and replacing the exterior entrances, including the entrance plaza:

Entry Plaza: The plaza that covers the "catacomb" area will have clear sealer applied to the sloped portions of the concrete walls enclosing the catacombs. The raised plaza portions will have waterproofing and pavers installed over the existing concrete. The existing paving at the entrance plaza will be removed and a new waterproof membrane and new paving will be installed.

North and South Curtain Wall: The north and south curtain walls of Wilson Hall are comprised of an anodized aluminum framing system that extends the full height of the building. The lower six floors of the system are sloped but do not have the current code required safety glazing. The finish of the aluminum framing is deteriorating and the system is allowing water penetration into the building. Safety glazing will be installed and the system will be repaired to resolve the water penetration.

4. Details of Cost Estimate [a]

	(dollars in thousands) Current Estimate	Previous Estimate
Design Phase		
Preliminary and Final Design costs	840	920
Project Management costs (0.8% of TEC)	130	100
Total, Engineering design inspection and administration of construction costs (6.2% of TEC)	970	1,020
Construction Phase		
Buildings	8,520	8,850
Inspection, design and project liaison, testing, checkout and acceptance	810	870
Construction Management (10.6% of TEC)	1,660	1,820
Project Management (2.6% of TEC)	400	430
Total, Construction Costs	11,390	11,970
Contingencies		
Design Phase (1.6% of TEC)	250	170
Construction Phase (19.2% of TEC)	2,990	2,440
Total, Contingencies (20.8% of TEC)	3,240	2,610
Total, Line Item Cost (TEC)	15,600	15,600

5. Method of Performance

Overall project management, quality assurance, supervision of design and construction efforts and coordination with the U.S. Department of Energy for this project will be the responsibility of the Fermi National Accelerator Laboratory, through the Facilities Engineering Services Section (FESS). Design will be accomplished by a combination of FESS staff and consultant A/E fixed price contracts under the direction of the Facilities Engineering Services Section. Construction for project completion will be accomplished by means of one or more competitively bid, fixed price construction subcontracts. Construction Management and overall project management during the construction phase of this project will remain the responsibility of the Facilities Engineering Services Section of the Fermi National Accelerator Laboratory.

[a] The economic escalation rates from FY 1997 dollars for FY 1999 through FY 2001 are 5.3%, 2.9%, and 2.9% respectively from the Department Price Change Index FY 1999 Guidance, General Construction.

6. Schedule of Project Funding

(dollars in thousands)

	Prior Years	FY 1999	FY 2000	FY 2001	Outyears	Total
Project Cost						
Facility Cost						
Total, Line item TEC	0	674	6,340	6,990	1,596	15,600
Other Project Costs						
Conceptual design cost	1,100	0	0	0	0	1,100
Other project-related costs [a]	0	490	350	850	410	2,100
Total, Other Project Costs	1,100	490	350	850	410	3,200
Total Project Cost (TPC)	1,100	1,164	6,690	7,840	2,006	18,800

7. Related Annual Funding Requirements

	Current Estimate	Previous Estimate
Wilson Hall related annual costs	NA	NA
Incremental utility costs (estimate based on FY 1997 rate structure)	NA	NA
Total related annual funding *(operating from FY 2003 through FY 2007)* [b]	NA	NA

[a] Includes funding for relocation of tenants before and after the construction and rebuilding of their workspaces; refurbishment of existing elevators which will be used for construction purposes, and then restored to public use.

[b] No incremental annual operating costs will result from the completion of this project.

00-G-307, Research Office Building, Stanford Linear Accelerator Center, Stanford, California

(Changes from FY 2000 Congressional Budget Request are denoted with a vertical line [|] in the left margin.)

1. Construction Schedule History

	Fiscal Quarter				Total Estimated Cost ($000)	Total Project Cost ($000)
	A-E Work Initiated	A-E Work Completed	Physical Construction Start	Physical Construction Complete		
FY 2000 Budget Request	1Q '00	3Q '00	4Q '00	4Q '01	7,200	7,430
FY 2001 Budget Request	1Q '00	3Q '00	4Q '00	4Q '01	7,200	7,430

2. Financial Schedule

(dollars in thousands)

Fiscal Year	Appropriations	Obligations	Costs
Construction			
2000	2,000	2,000	950
2001	5,200	5,200	6,250

3. Project Description, Justification and Scope

The new Research Office Building project will construct a two-story building with approximately 30,000 gross square feet that will provide permanent, energy efficient office and conference space to meet the needs of the Laboratory. The office building will be located immediately adjacent to and north of the existing SLAC Administrative and Engineering building in the central campus area of the Laboratory. The new government-owned facility described herein will be located on leased land. Features include fixed and flexible office areas, meeting rooms and conference facilities equipped with interior office furnishings. Conventional utilities, such as domestic water, sanitary sewer, HVAC, and electrical power, will be provided by short connections from existing services. Specialized utilities include HVAC control and equipment, telecommunication for video and computers, and the main electrical feed. Construction of this building may allow the demolition of several very old, temporary structures, totaling approximately 17,000 square feet.

This building will provide adequate facilities for the BaBar experimental program. This experimental program is critical to delivering the scientific understanding necessary to the success of the DOE's and the Nation's long-term science objective of maintaining the U.S. high energy physics program at the forefront of basic research.

With the increasing level of activity associated with the BaBar collaboration and SLAC's on-going high energy physics (HEP) experimental program, SLAC's space requirements are projected to exceed the capacity of currently existing office and meeting facilities. The BaBar experiment, which began operation in FY 1999, projects a large influx of users who will require adequate office and support space. SLAC expects to host approximately 1,100 HEP users per year as the BaBar experiment ramps up to full scale operations. The BaBar collaboration itself, consists of over six hundred users from around the world representing over seventy institutions. Office and meeting space is urgently needed to meet the demand created by this mega-collaboration. In the past, SLAC has only had about 200 collaborators/users in residence at any one time. Even at this level, most are housed in less than adequate facilities (the user community has become ever more vocal about this in the past year or two). In the BaBar era, SLAC expects substantially more users to be in residence and, as a national user facility, SLAC needs to be in a position to provide adequate space for them.

SLAC has investigated leasing and conversion alternatives to meet the projected need for office space but none has been judged to be as cost effective or satisfactory as the addition of the new office building. It was determined that there was insufficient off-site office space available nearby for leasing (12,000 square feet with a rental cost of $1,000,000 per year was available). Conversion of existing temporary and permanent facilities is not cost effective because the cost of renovation and necessary seismic and ADA work is roughly equal to the cost of new construction and the resulting space is inferior to new space specifically designed for office use. Additionally, valuable industrial space would be lost.

The use of substandard facilities could meet approximately two-thirds of this projected need but at substantial cost for necessary remedial work. With improved operating and energy efficiencies, it is estimated that the annual operating costs for this 30,000 square foot building will be equal to the current operating costs of the 17,000 square feet of temporary space to be removed.

If the new Research Office Building is not constructed, operating efficiencies and cost savings cannot be achieved, existing temporary structures, which are maintenance intensive and energy inefficient cannot be eliminated, the cost of seismic and ADA retrofitting will not be avoided, and parking will continue to be an operational deficiency in the main Computer Center area. Vehicular and pedestrian safety will not be improved. Commitments made to Stanford University and the SLAC HEP user population will not be met. An estimated $2,000,000 of avoidable costs will be incurred.

4. Details of Cost Estimate [a]

	(dollars in thousands)	
	Current Estimate	Previous Estimate
Design Phase		
Preliminary and Final Design costs	419	419
Design Management costs (1.4% of TEC)	98	98
Project Management costs (1.4% of TEC)	98	98
Total, Design Phase (8.5% of TEC)	615	615
Construction Phase		
Building	4,727	4,727
Specialized Utilities	519	519
Standard Equipment	496	496
Construction Management (1.6% of TEC)	113	113
Project Management (1.2% of TEC)	85	85
Total, Construction Costs	5,940	5,940
Contingencies		
Design Phase (0.8% of TEC)	61	61
Construction Phase (8.1% of TEC)	584	584
Total, Contingencies (9.0% of TEC)	645	645
Total, Line Item Cost (TEC)	7,200	7,200

5. Method of Performance

Construction and procurement shall be accomplished by fixed price subcontracts on the basis of competitive bidding. Design and inspection shall be performed by the laboratory and contracted Architect-Engineers.

[a] Escalated to mid-point of construction with a factor of 1.0611. Allocated Indirects included in costs.

6. Schedule of Project Funding

(dollars in thousands)

	Prior Years	FY 1999	FY 2000	FY 2001	Outyears	Total
Project Cost						
Facility Cost						
Design	0	0	615	0	0	615
Construction	0	0	335	6,250	0	6,585
Total Facility Costs (TEC)	0	0	950	6,250	0	7,200
Other Project Costs						
Conceptual design cost	0	30	0	0	0	30
Other project related costs [a]	0	0	0	200	0	200
Total, Other Project Costs	0	30	0	200	0	230
Total Project Cost (TPC)	0	30	950	6,450	0	7,430

7. Related Annual Funding Requirements

(FY 2002 dollars in thousands)

	Current Estimate	Previous Estimate
Annual facility maintenance/repair costs [b]	39	34
Incremental utility costs [c]	41	36
Total related annual funding	80	70
Total Operating costs (operating from FY 2003 through FY 2007)	400	350

[a] Includes funding for demolition of temporary structures; paving.

[b] Includes costs for janitorial services.

[c] Includes incremental utility costs for electric power and water.

Nuclear Physics

Program Mission

The Nuclear Physics program of the Department of Energy (DOE) has the lead responsibility for Federal support of nuclear physics research and supports fundamental research activities under the mandate provided in Public Law 95-91 that established the Department. The primary mission of the program is to support the basic research scientists, develop and operate the facilities, and foster the technical and scientific activities needed to understand the structure and interactions of atomic nuclei, and the fundamental forces and particles of nature as manifested in nuclear matter. Atomic nuclei can be described as a collection of nucleons (protons and neutrons), bound together by the mechanism of exchange of mesons, mainly pi mesons (pions). The research forefront in nuclear physics now includes incorporation of the quark substructure of the nucleon into the understanding of nuclear structure and of quark-antiquark pairs to form the mesons. Quarks, which are the most elementary building blocks of matter, are bound together in groups of three by the exchange of gluons to form the nucleons.

Attendant upon this core mission are responsibilities to enlarge and diversify the Nation's pool of technically trained talent and to facilitate transfer of technology and knowledge acquired to support the Nation's economic base. The program works in close coordination with the Nuclear Physics program at the National Science Foundation (NSF) and, jointly with the NSF, charters the Nuclear Science Advisory Committee to provide advice on scientific opportunities and priorities.

The high quality of the research in this program is continuously evaluated through the use of merit based peer review and scientific advisory committees.

Program Goal

Understand the properties and behavior of atomic nuclei and nuclear matter, and the fundamental forces involved, based on a series of systematic experimental and theoretical scientific investigations.

Program Objectives

- Conduct a program of maximum effectiveness to provide new insights into the nature of energy and subatomic matter, based on evaluation by rigorous peer review.
- Conceive, develop, construct, and operate world class scientific accelerator facilities in a timely and effective manner. In the execution of this responsibility, together with other Office of Science organizations, act as the Nation's leader in developing management techniques to optimize construction and operation of facilities in a cost effective, safe, and environmentally responsible manner.
- Leverage United States objectives by means of international cooperation through exchanges of scientists and participation in cooperative projects.
- Continue the advanced education and training activities of young scientists to maintain the skills and conceptual underpinning of the Nation's broad array of nuclear related sciences and technologies.

Performance Measures

- Evaluate the scientific quality and capability of the total DOE Nuclear Physics program to maintain the United States position as world leader in nuclear physics research. Evaluations will be based on rigorous peer reviews conducted by recognized scientific experts.
- Determine the production trends of diverse, highly trained young scientists - an essential ingredient for the vitality of the nation's technological base - using the Nuclear Physics annual census of scientific personnel. Funding patterns of university grants will include consideration of the optimum production rate of scientists.
- Use the assistance of technical experts to monitor the performance of construction projects for world class nuclear physics facilities and instrumentation. Measure project performance against cost and schedule milestones contained in project plans. Working with the relevant DOE project manager and laboratory project management, identify and establish programmatic modifications needed to enable projects to meet schedules and costs.
- Select research projects through a peer-reviewed, merit-based competitive process.
- Use peer reviews and user feedback to monitor the effectiveness of facility operations. Evaluate facility performance against objectives set in program guidance based on funding availability, and measure achieved beam hour availability against guidelines. Develop appropriate facility funding profiles to best provide overall research productivity for the Nuclear Physics program. Operate research facilities in a manner that meets user requirements as indicated by achieving performance specifications while protecting the safety of the workers and the environment, and by the level of endorsement by user organizations.
- Measure the progress and success of the Nuclear Physics program in responding to priorities and recommendations contained within the long range plan of the DOE/NSF Nuclear Science Advisory Committee (NSAC), as measured by NSAC's evaluation letter to the Nuclear Physics program.
- Continue collaborative efforts with NASA to use beams at Brookhaven National Laboratory to study the effects of radiation on biological and electronic systems in space.
- Complete fabrication of the BLAST detector at MIT/Bates in FY 2001 in accordance with the established baseline and as measured against the detailed project milestones.

Significant Accomplishments and Program Shifts

- In FY 2000, the Nuclear Physics Program initiated an Outstanding Junior Investigator (OJI) program to recognize and support young promising scientists pursuing nuclear physics research.

Medium Energy Nuclear Physics

- In FY 1999, the Continuous Electron Beam Accelerator Facility (CEBAF) at Thomas Jefferson National Accelerator Facility (TJNAF) provided beams up to 5.5 GeV to all three experimental halls for research with polarized and unpolarized beams. Application of improved conditioning of the accelerator cavities is expected to increase the energy to 6 GeV by FY 2001.
- Precision measurements performed with new world-class polarized electron beams at TJNAF in FY 1999 provide important new insight into the role of the strange quark in determining the fundamental properties of the nucleon.

- An international collaboration (HERMES), involving several US Nuclear Physics Groups, presented results in FY 1999 indicating that gluons are responsible for a significant fraction of the observed spin of the nucleon, based on measurements performed at the DESY accelerator in Germany.
- In FY 1999, over 80 milliamperes of a 660 MeV stored electron beam in the Bates South Hall Ring was directed through a hydrogen internal gas target at the location of the BLAST detector. This was a significant milestone in the development of capabilities for the planned BLAST research program.
- In FY 2001, the BLAST detector at the MIT/Bates Linear Accelerator Center facility will be completed and will initiate commissioning for a research program in FY 2002-2004 studying the structure of the nucleon and few-body nuclei. Upon completion of the BLAST research program in FY 2004, the Bates facility will begin a 2-year phaseout.
- In FY 2001, the Brookhaven Medium Energy Group will be re-directed to emphasize a program directed at understanding the origin of the spin of the proton at the new RHIC facility. A limited program of fixed target experiments will be supported at the AGS.

Heavy Ion Nuclear Physics

- In FY 1999, the following performance goal was fully met:
  - Complete construction and begin operation of the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory.
- In FY 1999, the Relativistic Heavy Ion Collider (RHIC) construction project at Brookhaven National Laboratory (BNL) was completed on schedule and within budget. In FY 2001, RHIC will approach full luminosity following initial operation in FY 2000. Fabrication of detectors, including the additional experimental equipment recommended by NSAC for purposes of particle detection and data analysis, will be largely completed, as scheduled. Four experiments (STAR, PHENIX, BRAHMS and PHOBOS) involving over 950 researchers and students from 90 institutions and 19 countries will pursue a vigorous research program.
- In FY 1999, observations of two new elements (Z=116 and 118) were reported in measurements performed at the LBNL 88-Inch Cyclotron using the Berkeley Gas-filled Spectrometer (BGS). Continued measurements are planned for FY 2000 and FY 2001.
- In FY 1999, the NSAC Isotope Separation On-Line (ISOL) Task Force, identified an optimal configuration for a next generation Rare Isotope Accelerator (RIA). RIA is a facility where short-lived nuclei (with lifetimes of greater than a thousandth of a second) are produced in nuclear reactions using intense beams of stable nuclei, then extracted and accelerated in a post-accelerator to be used in experiments. RIA would provide unique, world-class capabilities for the low energy, nuclear astrophysics and nuclear structure communities for several decades. R&D and preconceptual design activities will continue in FY 2000 and FY 2001.
- In FY 1999, Gammasphere coupled with the Fragment Mass Separator at the ANL ATLAS facility, provided surprising results on the structure of the Nobelium isotope (^{254}No) showing that nuclear shell structures, which are entirely responsible for the stability of nuclei with charges greater than 100, persist up to very high deformation.
- In FY 2000, Gammasphere will be moved from the ANL ATLAS facility to the LBNL 88-Inch Cyclotron facility for a research program that will utilize the capabilities of the 88-Inch Cyclotron.
- Measurements performed in FY 1999 at the ATLAS facility have established properties of nuclei and reaction processes that allow for more stringent tests of models for supernova collapses and improved predictions for chemical element production in stellar burning and supernovae.

- In FY 1999, researchers at the Texas A&M Cyclotron facility developed a new method for establishing very low energy proton capture cross sections that are critical to astrophysical modeling of the production of the chemical elements of our universe. This is expected to lead to significantly improved astrophysics predictions.

Low Energy Nuclear Physics

- The US/Canadian Sudbury Neutrino Observatory (SNO) detector was completed and initiated data taking in FY 1999. Initial results, of measurements of solar neutrinos fluxes relevant to the question of whether neutrinos have mass, are anticipated in FY 2001.
- In FY 1999, the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory (ORNL) completed a series of experiments that provide input to refined astrophysical calculations for the breakout from the Carbon-Nitrogen-Oxygen (CNO) cycle responsible for element production beyond oxygen. An expanded series of measurements will be carried out in FY 2000-2001 as new beam species are developed and beam intensities increase.
- In FY 1999, at the ORNL Oak Ridge Electron Linear Accelerator (ORELA) facility, precision measurements of neutron capture cross sections on Neodymium and Barium isotopes have provided the critical data necessary to use precision meteorite abundance results to test the new astrophysical Red Giant Stardust Model for heavy element production.

Nuclear Theory

- University theorists made a significant step forward in our understanding of how and where the heavier elements observed in nature were originally produced with strong evidence that they were created in neutron rich gas at the core of supernova explosions.
- Theorists at universities and the national laboratories, in several collaborative efforts, have developed increasingly sophisticated models of the reactions between ultra relativistic heavy ions, such as will be produced in the Relativistic Heavy Ion Collider facility at the Brookhaven National Laboratory. In the past year, several new and potentially clear signals indicative of the creation of the quark-gluon plasma in such collisions were suggested by these models.
- Recently, national laboratory theorists have found, quite unexpectedly, that effects due to special relativity can explain a symmetry in the low lying states of nuclei that is observed in a large number of nuclei, but for which there was previously no satisfactory explanation.
- In FY 2001, the Nuclear Theory Institute at the University of Washington continues its activities as a premier international center for new initiatives and collaborations in nuclear theory research.

Scientific Facilities Utilization

The Nuclear Physics request includes $250,180,000 to maintain support of the Department's scientific user facilities. This funding will provide research time for thousands of scientists in universities, Federal agencies, and U.S. companies. It will also leverage both Federally and privately sponsored research consistent with the Administration's strategy for enhancing the U.S. National science investment.

Funding of Contractor Security Clearances

In FY 1999, the Department divided the responsibility for obtaining and maintaining security clearances. The Office of Security Affairs, which was responsible for funding all Federal and contractor employee clearances, now pays only for clearances of Federal employees, both at headquarters and the field.

Program organizations are now responsible for contractor clearances, using program funds. This change in policy enables program managers to make the decisions as to how many and what level clearances are necessary for effective program execution. In this way, it is hoped that any backlog of essential clearances which are impeding program success can be cleared up by those managers most directly involved. The Office of Science is budgeting $88,000 for estimated contractor security clearances in FY 2000 and FY 2001; respectively, within this decision unit.

Workforce Development

The Nuclear Physics program supports development of the R&D workforce through support of undergraduate researchers, graduate students working toward a doctoral degree, and postdoctoral associates developing their research and management skills. The R&D workforce developed under this program not only provides new scientific talent in areas of fundamental research, but also in a wide variety of technical, medical, and industrial areas requiring the finely honed thinking and problem solving abilities and computing and technical skills developed through an education and experience in a fundamental research field. Scientists trained as Nuclear Physicists can be found in such diverse areas as hospitals (nuclear medicine and medical physics), space exploration, and the stock market.

The 814 post-doctoral Associates and graduate students supported by the Nuclear Physics program in FY 1999 were involved in a large variety of experimental and theoretical research. Nearly one third are involved in theoretical research. Those involved in experimental research utilize a number of scientific facilities supported by the DOE, NSF, and foreign countries. The majority of the 510 postdoctoral associates and graduate students doing experimental research in FY 1999 did their work at the six Nuclear Physics Scientific User Facilities: ATLAS (ANL), 88-Inch Cyclotron (LBNL), HRIBF (ORNL), Bates Accelerator Center (MIT), RHIC (BNL), and Jefferson Lab (TJNAF in Virginia).

Funding Profile

(dollars in thousands)

	FY 1999 Current Appropriation	FY 2000 Original Appropriation	FY 2000 Adjustments	FY 2000 Current Appropriation	FY 2001 Request
Nuclear Physics					
Medium Energy Nuclear Physics	115,695	121,250	-2,400	118,850	125,405
Heavy Ion Nuclear Physics	146,905	180,775	-1,365	179,410	192,360
Low Energy Nuclear Physics	32,308	34,145	-366	33,779	33,970
Nuclear Theory	15,640	15,830	-155	15,675	18,155
Subtotal, Nuclear Physics	310,548	352,000	-4,286	347,714	369,890
Construction	16,620	0	0	0	0
Subtotal, Nuclear Physics	327,168	352,000	-4,286	347,714	369,890
Use of Prior Year Balances	-776[a]	0	0	0	0
General Reduction	0	-2,407	2,407	0	0
Contractor Travel	0	-695	695	0	0
Omnibus Rescission	0	-1,184	1,184	0	0
Total, Nuclear Physics	326,392[b]	347,714	0	347,714	369,890[c]

Public Law Authorization:

Public Law 95-91, "Department of Energy Organization Act"

Public Law 103-62, "Government Performance Results Act of 1993"

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $6,969,000 that has been transferred to the SBIR program and $418,000 which has been transferred to the STTR program.

[c] Includes $5,957,000 for Waste Management activities at Brookhaven National Laboratory that was previously budgeted in FY 1999 and FY 2000 in the Environmental Management program.

Funding by Site

	(dollars in thousands)				
	FY 1999	FY 2000	FY 2001	$ Change	% Change
Albuquerque Operations Office					
Los Alamos National Laboratory	10,505	9,986	10,095	+109	+1.1%
Chicago Operations Office					
Argonne National Laboratory	17,039	16,304	16,965	+661	+4.1%
Brookhaven National Laboratory	117,305	132,463	145,783	+13,320	+10.1%
Chicago Operations Office	52,218	48,507	50,016	+1,509	+3.1%
Total, Chicago Operations Office	186,562	197,274	212,764	+15,490	+7.9%
Idaho Operations Office					
Idaho National Engineering and Environmental Laboratory	80	0	0	0	0.0%
Oakland Operations Office					
Lawrence Berkeley National Laboratory	23,222	17,232	17,250	+18	+0.1%
Lawrence Livermore National Laboratory	710	564	785	+221	+39.2%
Oakland Operations Office	14,425	16,246	16,283	+37	+0.2%
Total, Oakland Operations Office	38,357	34,042	34,318	+276	+0.8%
Oak Ridge Operations Office					
Oak Ridge Institute for Science & Education	585	559	650	+91	+16.3%
Oak Ridge National Laboratory	16,094	15,173	16,120	+947	+6.2%
Thomas Jefferson National Accelerator Facility	71,673	72,730	74,715	+1,985	+2.7%
Oak Ridge Operations Office	123	81	64	-17	-21.0%
Total, Oak Ridge Operations Office	88,475	88,543	91,549	+3,006	+3.4%
Richland Operations Office					
Richland Operations Office	1,900	0	0	0	0.0%
Washington Headquarters	1,289	17,869	21,164	+3,295	+18.4%
Subtotal, Nuclear Physics	327,168	347,714	369,890	+22,176	+6.4%
Use of Prior Year Balances	-776[a]	0	0	0	0.0%
Total, Nuclear Physics	326,392[b]	347,714	369,890[c]	+22,176	+6.4%

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $6,969,000 that has been transferred to the SBIR program and $418,000 which has been transferred to the STTR program.

[c] Includes $5,957,000 for Waste Management activities at Brookhaven National that was previously budgeted in FY 1999 and FY 2000 in the Environmental Management program.

Site Description

Argonne National Laboratory

Argonne National Laboratory (ANL) in Argonne, Illinois, is a Multiprogram Laboratory located on a 1,700 acre site in suburban Chicago. ANL has a satellite site located in Idaho Falls, Idaho. At Argonne, the Nuclear Physics program supports: (1) the Heavy Ion group, which operates the ATLAS Heavy Ion accelerator as a national user facility, and carries out related research; (2) the Medium Energy group, which carries out a program of research at TJNAF, Fermilab, and DESY in Germany; also supported are activities leading to a "spin" physics program at RHIC; (3) R&D directed at a proposed advanced Rare Isotope Accelerator (RIA) facility; (4) the Nuclear Theory group which carries out theoretical calculations and investigations in subjects supporting the experimental research programs in Medium Energy and Heavy Ion physics; and (5) data compilation and evaluation activities as part of the national data program.

Brookhaven National Laboratory (BNL)

Brookhaven National Laboratory is a Multiprogram Laboratory located on a 5,200 acre site in Upton, New York. The major effort at BNL, supported by the Heavy Ion Program, is the new Relativistic Heavy Ion Collider (RHIC) which uses the Tandem, Booster and Alternating Gradient Synchrotron (AGS) accelerators in combination as an injector. The RHIC facility is a major new and unique international user facility. RHIC will search for the predicted "quark-gluon plasma," a form of nuclear matter not previously observed. The Medium Energy program will use polarized protons in RHIC to understand the internal "spin" structure of the protons and pursue a limited program of fixed target experiments at the AGS. The Laser Electron Gamma Source (LEGS) group uses a unique polarized photon beam to carry out a program of photonuclear spin physics at the National Synchrotron Light Source (NSLS). The BNL Nuclear Theory group provides theoretical support and investigations primarily in the area of relativistic heavy ion physics. Low Energy support is provided for detector and chemical analysis development for the Sudbury Neutrino Observatory (SNO) and involvement in the SNO research program. BNL's DOE-managed National Nuclear Data Center is the central U.S. site for the American and international nuclear data and compilation effort.

Idaho National Engineering & Environmental Laboratory (INEEL)

Idaho National Engineering and Environmental Laboratory is a Multiprogram Laboratory located on 572,000 acres in Idaho Falls, Idaho. At INEEL, the program of nuclear data and compilation directly supported by the Nuclear Physics program, has been phased out.

Lawrence Berkeley National Laboratory (LBNL)

Lawrence Berkeley National Laboratory is a Multiprogram Laboratory located in Berkeley, California. The Lab is on a 200 acre site adjacent to the Berkeley campus of the University of California. At LBNL, the Nuclear Physics program supports: (1) operations and research at the 88-inch Cyclotron, a heavy ion accelerator which is run as a national user facility; (2) the Relativistic Nuclear Collisions group, with activities primarily at RHIC, where they have been major players in the development of the large STAR detector; (3) the Low Energy group, which plays a major role in the implementation and operation of the Sudbury Neutrino Observatory (SNO) detector; (4) the Nuclear Theory group, which carries out a program with emphasis on theory of relativistic heavy ion physics; and (5) the Nuclear Data group whose activities support the National Nuclear Data Center at BNL.

Lawrence Livermore National Laboratory (LLNL)

Lawrence Livermore National Laboratory is a Multiprogram Laboratory located on a 821 acre site in Livermore, California. Low Energy Research support is provided for nuclear structure studies carried out primarily at the GENIE detector at the LANSCE facility at Los Alamos National Laboratory, and for nuclear data and compilation activities.

Los Alamos National Laboratory (LANL)

Los Alamos National Laboratory is a Multiprogram Laboratory located on a 27,000 acre site in Los Alamos, New Mexico. Nuclear Physics supports a broad program of research including: (1) a program of neutron beam research which utilizes beams from the LANSCE facility; (2) a relativistic heavy ion effort using the PHENIX detector at the new Relativistic Heavy Ion Collider (RHIC); (3) research directed at the study of the quark substructure of the nucleon in experiments at Fermilab, and at the "spin" structure of nucleons at RHIC using polarized proton beams; (4) the development of the Sudbury Neutrino Observatory (SNO) detector as well as involvement in the planned research program; (5) a broad program of theoretical research into a number of topics in nuclear physics; (6) nuclear data and compilation activities as part of the national nuclear data program.

Oak Ridge Institute for Science and Education (ORISE)

Oak Ridge Institute for Science and Education is located on a 150 acre site in Oak Ridge, Tennessee. Nuclear Physics support is provided through ORISE for activities in support of the Holifield Radioactive Ion Beam Facility (HRIBF) and its research program.

Oak Ridge National Laboratory (ORNL)

Oak Ridge National Laboratory is a Multiprogram Laboratory located on a 24,000 acre site in Oak Ridge, Tennessee. The major effort at ORNL is the Low Energy program support for research and operations of the Holifield Radioactive Ion Beam Facility (HRIBF), which is run as a national user facility. HRIBF allows a program of experimental research in nuclear structure and reaction processes important for astrophysics. Also supported is a relativistic heavy ion group which is involved in a research program using the PHENIX detector at RHIC. The theoretical nuclear physics effort at ORNL emphasizes investigations of nuclear structure and astrophysics. Nuclear data and compilation activities are also supported as part of the national nuclear data effort.

Thomas Jefferson National Accelerator Facility (TJNAF)

Thomas Jefferson National Accelerator Facility (TJNAF) is a program-dedicated laboratory (Nuclear Physics) located on 273 acres in Newport News, Virginia. Major Medium Energy program support is provided for the operation and research program of TJNAF, a unique international user facility for the investigation of nuclear and nucleon structure based on the underlying quark substructure. Also supported is a nuclear theory group whose program of investigations support the experimental program of the laboratory. The Nuclear Physics program provides most of the support for this new single purpose laboratory.

All Other Sites

The Nuclear Physics program funds 160 research grants at 87 colleges/universities located in 35 states. Also included are funds for research awaiting distribution pending completion of peer review results.

Medium Energy Nuclear Physics

Mission Supporting Goals and Objectives

The Nuclear Physics Program supports the basic research necessary to identify and understand the fundamental features of atomic nuclei and their interactions. The Medium Energy Nuclear Physics subprogram supports fundamental research that is ultimately aimed at achieving an understanding of the structure of the atomic nucleus in terms of the quarks and gluons, the objects that are believed to combine in different ways to make all the other sub-atomic particles. Equally important is the achievement of an understanding of the "strong force;" one of only four forces in nature, and the force that holds the nucleus of the atom together. Research efforts include studies of the role of excited states of protons and neutrons in nuclear structure, investigations of the role of specific quarks in the structure of protons and neutrons, studies of the symmetries in the behavior of the laws of physics, and investigations of how the properties of protons and neutrons change when embedded in the nuclear medium. Measurements are often carried out with beams of electrons or protons whose "spins" have all been lined up in the same direction (polarizing the beams) to determine unique "structure functions," and other indicators of the details of nuclear structure.

This research is generally carried out using higher energy electron and proton beams provided by accelerator facilities operated by this subprogram, other Department of Energy programs (e.g., High Energy Physics and Basic Energy Sciences) and at other unique domestic or foreign facilities. The Medium Energy Nuclear Physics subprogram supports the operations of two national user facilities - the Thomas Jefferson National Accelerator Facility (TJNAF) and the Bates Linear Accelerator Center operated by the Massachusetts Institute of Technology. These accelerator facilities serve a nationwide community of Department of Energy and National Science Foundation supported scientists from over 100 American institutions, of which over 90% are universities. Both facilities provide major contributions to American education at all levels. At both TJNAF and Bates, the National Science Foundation (NSF) has made a major contribution to new experimental apparatus in support of the large number of NSF users. A significant number of foreign scientists collaborate in the research programs of both facilities. The research program at the new TJNAF, for example, involves over 250 scientists from 19 foreign countries; many of these scientists are from Conseil Europeen pour la Recherche Nucleaire (CERN) member states. At TJNAF, foreign collaborators have also made major investments in experimental equipment.

Performance Measures

- Complete fabrication of the BLAST detector at MIT/Bates in accordance with the project milestones.

Funding Schedule

	(dollars in thousands)				
	FY 1999	FY 2000	FY 2001	$ Change	% Change
Research					
University Research	16,729	16,422	16,945	+523	+3.2%
National Laboratory Research	19,649	19,961	20,430	+469	+2.3%
Other Research	399[a]	5,067	5,355	+288	+5.7%
Subtotal, Research	36,777	41,450	42,730	+1,280	+3.1%
Operations					
TJNAF Operations	65,418	66,515	68,400	+1,885	+2.8%
Bates Operations	13,500	10,885	12,775	+1,890	+17.4%
Other Operations	0	0	1,500	+1,500	+100.0%
Subtotal, Operations	78,918	77,400	82,675	+5,275	+6.8%
Total, Medium Energy Nuclear Physics	115,695	118,850	125,405	+6,555	+5.5%

Detailed Program Justification

(dollars in thousands)		
FY 1999	FY 2000	FY 2001

Research

University Research

These activities comprise a broad program of research, and include 42 grants at 33 universities in 17 states and the District of Columbia. These research efforts utilize not only each of the accelerator facilities supported under the Medium Energy program, but also use other U.S. and international accelerator laboratories. Included in University Research is Bates Research, the effort performed at the MIT/Bates Linear Accelerator Center by MIT scientists. Other University Research includes all other university-based efforts using many research facilities, including activities by MIT scientists that are not carried out at Bates.

Bates Research:

- At the MIT/Bates accelerator, MIT scientists along with other university researchers have completed “symmetry violation” studies on the proton in the North Experimental Hall. “Out-of-Plane” measurements are being carried out using new spectrometers in the South

[a] Excludes $4,059,000 which has been transferred to the SBIR program and $418,000 which has been transferred to the STTR program.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
Experimental Hall on the proton, deuteron, and complex nuclei including measurements of the transition of the proton to its excited state.			
‣ Preparations are being made for a new program of research utilizing the new BLAST large acceptance detector whose fabrication will be completed in FY 2001. BLAST will be used in conjunction with thin gas targets and the high current circulating electron beam in the South Hall Pulse Stretcher Ring.	4,700	4,500	4,200

Other University Research:

- University scientists are collaborating on important ongoing and future experiments at TJNAF. FY 2001 activities include the completion of studies of the charge structure of the neutron in Hall C, planned measurements include the electric form factor of the proton, and a series of planned studies of the excited states of the proton in Hall B. First parity-violation measurements to look for the "strange quark" content of the proton in Hall A have been completed. Plans are also underway to carry out a program of high resolution hypernuclear spectroscopy in Hall A. Scientists are participating in a major new detector being assembled for the "G0" experiment in cooperation with the National Science Foundation. "G0" will allow a "complete mapping" of the strange quark content of the nucleon using parity violation techniques.
- A number of university groups are collaborating in experiments using the new Out-of-Plane spectrometers in the South Experimental Hall at the MIT/Bates Linear Accelerator Center. BLAST will be completed in FY 2001 and university research support will be provided.
- University scientists and National Laboratory collaborators will continue to carry out the HERMES experiment at the DESY laboratory in Hamburg, Germany. This experiment is measuring what components of the proton or neutron determine the "spin" of these particles, an important and timely scientific issue. In FY 2001, HERMES will continue to utilize a new Ring Imaging Cerenkov counter for particle identification.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
‣ The Palo Verde neutrino detector has been searching for neutrino oscillations using the Palo Verde nuclear power reactors near Phoenix, Arizona as the source of neutrinos. Recent measurements suggesting that such oscillations exist, implying neutrinos have mass, have a major impact on our understanding of the laws of physics. In FY 2001, the experimental program will be complete and data analysis will be underway.	12,029	11,922	12,745
Total, University Research...	16,729	16,422	16,945

National Laboratory Research

Included is: (1) the research supported at the Thomas Jefferson National Accelerator Facility (TJNAF), that houses the Nation's and World's unique high intensity continuous wave electron accelerator and (2) research efforts at Argonne, Brookhaven, and Los Alamos National Laboratories. The National Laboratory groups carry out research at various world facilities as well as at their home institutions.

TJNAF Research:

	FY 1999	FY 2000	FY 2001
‣ Scientists at TJNAF, with support of the user community, assembled the large and complex new experimental apparatus for Halls A, B, and C. All three experimental Halls are operational. TJNAF scientists provide experimental support and operate the apparatus for safe and effective utilization by the user community. TJNAF scientists participate in the laboratory's research program, and collaborate in research at other facilities. ‣ As of FY 2000, twelve experiments will have been completed in Hall C. Ten experiments will have been completed in Hall A. The complex large-acceptance spectrometer in Hall B is complete and the research program is well underway. Three major experiments will have been completed, and partial data will have been accumulated on many more. ‣ TJNAF scientists are participating in the assembly of a new detector for the "G0" experiment, in cooperation with the National Science Foundation.	5,760	5,680	5,800

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001

Other National Laboratory Research:

- Argonne National Laboratory scientists are pursuing research programs at TJNAF, at the DESY Laboratory in Germany, and have proposed measurements of the quark structure of the nucleon at the new Main Injector at Fermilab. The theme running through this entire effort is the search for a detailed understanding of the internal structure of the nucleon.
- At Brookhaven National Laboratory, the Medium Energy Research group, that in previous years has concentrated on hadron beam experiments at the AGS, will change its emphasis. Since the AGS will now serve as a heavy ion and proton injector for the new RHIC accelerator, the group's scientific emphasis will shift to "RHIC Spin". This is the set of experiments planned for RHIC that will use colliding polarized proton beams to investigate the spin content of the nucleon. In FY 2001, additional funding is being provided to this group to assure that maximum scientific effort has been assembled in support of the RHIC Spin effort. A limited program of fixed target experiments will continue at the AGS, including an important study of hypernuclei for which the Japanese are major collaborators.
- Also at Brookhaven, Laser Electron Gamma Source (LEGS) scientists will be utilizing a new spectrometer and polarized target for a program of spin physics at low energies. This unique facility produces its high energy polarized "gammas" by back scattering laser light from the circulating electron beam at the National Synchrotron Light Source (NSLS). In FY 2001, the research program utilizing the new equipment will be fully underway.
- At Los Alamos National Laboratory, scientists and collaborators will be preparing to carry out a next generation neutrino oscillation experiment (BooNE), that builds on the experience of the Liquid Scintillator Neutrino Detector (LSND) experiment at Los Alamos that detected a signal of neutrino oscillations. If oscillations are proven, then neutrinos would have mass, requiring changes in our present understanding of the laws of physics. BooNE will be built at the Fermi

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
National Accelerator Laboratory (Fermilab), and will use neutrinos generated by the proton beam from the Fermilab Booster.			
‣ Los Alamos National Laboratory scientists and collaborators are also developing unique cold and ultra-cold neutron facilities at the Los Alamos Neutron Science Center (LANSCE). Difficult new experiments using these "very low energy" techniques will be supported and promise to provide important new information on some of the fundamental laws of physics.			
‣ Los Alamos scientists will also continue to be involved in experiments at Fermilab and at RHIC (RHIC Spin), that continue to try to unravel the mysteries of the internal components and spin of the nucleon. The Los Alamos group has also been instrumental in providing major components of the PHENIX detector at RHIC, that are crucial in carrying out the RHIC-Spin program of research.	13,889	14,281	14,630
Total, National Laboratory Research	19,649	19,961	20,430

Other Research

Other Research: Amounts include funds for the FY 2000 and FY 2001 SBIR and STTR programs and other established obligations which the Medium Energy Nuclear Physics subprogram must meet.

	FY 1999	FY 2000	FY 2001
‣ In FY 1999 $4,059,000 and $418,000 were transferred to the SBIR and STTR programs, respectively. The FY 2000 and FY 2001 amounts include the estimated requirement for the continuation of the SBIR and STTR programs	399	5,067	5,355
Total, Research	36,777	41,450	42,730

Operations

TJNAF Operations

Included is the funding that supports: (1) operation of the Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF), and (2) major manpower, equipment, and staging support for the assembly and dismantling of complex experiments.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001

TJNAF Accelerator Operations:

- The accelerator is now capable of delivering beams of differing energies and currents simultaneously to the three experimental halls. A maximum beam energy of 5.5 GeV has been delivered to experiments, and by FY 2001, 6 GeV will be readily available. Polarized beam capability is now also available and is being used for experiments.

	(hours of beam)		
	FY 1999	FY 2000	FY 2001
TJNAF...	4500	4500	4500

- AIP funding will provide for polarized injector and beam handling components that enable simultaneous polarized beam capability with varied operating parameters in the three experimental halls. AIP funding also supports other additions and modifications to the accelerator facilities. GPP funding is provided for minor new construction and utility systems..................... 41,500 42,405 44,075

TJNAF Experimental Support:

- Support is provided for the scientific and technical manpower, materials, and services needed to integrate rapid assembly, modification, and disassembly of large and complex experiments for optimization of schedules. This includes the delivery or dismantling of cryogenic systems, electricity, water for cooling, radiation shielding, and special equipment for specific experiments.
- The G0 detector, a major item of equipment with a Total Estimated Cost of $6,992,000 is being assembled. DOE's contribution is $3,387,000 and the National Science Foundation is contributing $3,605,000 to this detector. Capital equipment funding is also being used for assembly and installation of polarized electron injector improvements for the accelerator. Capital equipment funds will be used to install other ancillary equipment items such as polarized targets for experimental Halls A, B, and C, spectrometer systems,

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
complete a major upgrade of the data reduction system to handle massive amounts of raw data, and to continue fabrication of second generation experiments..................	23,918	24,110	24,325
Total, TJNAF Operations	65,418	66,515	68,400

Bates Operations

Funding is provided to support accelerator operations at the MIT/Bates Linear Accelerator Center.

- Bates will operate 2000 hours in FY 2001, to carry out a program of research and for commissioning activities for the BLAST detector. The laboratory will complete fabrication of the new BLAST detector, that will observe collisions in thin gas targets located on the South Hall Pulse Stretcher Ring. When the scientific program of BLAST commences at the end of FY 2001, the Bates research effort will concentrate on this new experimental facility. Upon completion of the BLAST research program in FY 2004, the Bates facility will begin a 2-year phaseout with operating funding reaching a D&D level of $2,500,000 in FY 2006. The total D&D cost and schedule will be determined at that time.

	(hours of beam)		
	FY 1999	FY 2000	FY 2001
Bates	1000	2000	2000

- Accelerator operations in FY 2001 are providing beams for research programs in the South Hall utilizing the OOPS spectrometers, for testing of internal, polarized, continuous beams in the South Hall Ring, and for development of extracted continuous beams for delivery to the existing South Hall spectrometers.

AIP funding supports additions and modifications to the accelerator facilities; GPP funding supports minor new construction and utility systems.	13,500	10,885	12,775

	FY 1999	FY 2000	FY 2001
Other Operations			
Funding is provided to support accelerator operations at other facilities.			
‣ Funding is provided for 600 hours of beam, to carry out a limited program of high priority experiments at the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory including an important study of hypernuclei for which the Japanese made a major investment in detector fabrication.	0	0	1,500
Total, Operations	78,918	77,400	82,675
Total, Medium Energy Nuclear Physics	115,695	118,850	125,405

(dollars in thousands)

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Research	
▪ **University Research**	
‣ The MIT/Bates research activity decrease reflects the funding profile of BLAST detector system.	-300
‣ Increase reflects effort to increase support for university scientists involved in research at TJNAF	+823
Total, University Research	+523
▪ **National Laboratory Research**	
‣ TJNAF research is increased to partially maintain level of effort.	+120
‣ Other National Laboratory research is increased to enhance the BNL Medium Energy Group's efforts in the RHIC Spin program, and to support National Laboratory scientists carrying out research at TJNAF.	+349
Total, National Laboratory Research	+469
▪ **Other Research**	
‣ Estimated SBIR/STTR and other obligations increase	+288
Total Research	+1,280

	FY 2001 vs. FY 2000 ($000)
Operations	
▪ **TJNAF Operations**	
‣ Funding for the Thomas Jefferson National Accelerator Facility allows accelerator operations to keep pace with inflation.	+1,670
‣ TJNAF experimental support funding nearly maintains level of effort.	+215
Total, TJNAF Operations	+1,885
▪ **Bates Operations**	
‣ MIT/Bates Linear Accelerator Center operations are being supported to complete a program of research with the Out-of-Plane (OOPS spectrometer system) and to develop the capabilities needed for the research program of the BLAST detector. When the BLAST detector is finished, the research effort will focus on this new detector facility.	+1,890
▪ **Other Operations**	
‣ A limited program of high priority experiments is being supported at the Brookhaven AGS commencing in FY 2001 including an important study of hypernuclei for which the Japanese made a major investment in detector fabrication.	+1,500
Total, Operations	+5,275
Total Funding Change, Medium Energy Nuclear Physics	+6,555

Heavy Ion Nuclear Physics

Mission Supporting Goals and Objectives

The Heavy Ion Nuclear Physics subprogram supports research directed at understanding the properties of atomic nuclei and nuclear matter over the wide range of conditions created in nucleus-nucleus collisions. Using beams of accelerated heavy ions at low bombarding energies, research is focused on the study of the structure of nuclei that are only gently excited (cool nuclear matter), but taken to their limits of energy, deformation, and isotopic stability. Such studies, as well as those directed at measuring nuclear reaction processes are important in understanding the production of the elements in stellar burning and supernovae. At much higher relativistic bombarding energies, the properties of hot, dense nuclear matter are studied with the goal of observing the deconfinement of normal matter into a form of matter, a quark-gluon plasma, which is believed to have existed in the early phase of the universe, a millionth of a second after the Big Bang.

Scientists and students at universities and national laboratories are funded to carry out this research at Department of Energy (DOE) supported facilities, as well as at National Science Foundation (NSF) and foreign supported accelerator facilities. The Heavy Ion Nuclear Physics subprogram supports and maintains accelerator facilities located at two universities (Texas A&M and Yale) and three National Laboratories (Argonne, Brookhaven and Lawrence Berkeley) for these studies. The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory, with initial production operation in FY 2000, is a unique world-class facility that addresses fundamental questions about the nature of nuclear matter. At the low-energy heavy ion national facilities (ANL-ATLAS and LBNL-88" Cyclotron) an expanded program of R&D and preconceptual design activities will be undertaken in support of a next generation low-energy facility, the Rare Isotope Accelerator (RIA). All the National Laboratory facilities are utilized by DOE, NSF and foreign supported researchers whose experiments undergo peer review prior to approval for beam time. Capital equipment funds are provided for detector systems, for data acquisition and analysis systems and for accelerator instrumentation for effective utilization of all the national accelerator facilities operated by this subprogram. Accelerator Improvement Project (AIP) funds are provided for additions, modifications, and improvements to the research accelerators and ancillary experimental facilities to maintain and improve the reliability and efficiency of operations, and to provide new experimental capabilities. The Heavy Ion Nuclear Physics subprogram also provides General Purpose Equipment (GPE) and General Plant Project (GPP) funds to Brookhaven National Laboratory (BNL) as part of Nuclear Physics' landlord responsibilities for this laboratory. These funds are for minor new construction, for other capital alterations and additions, and for improvements to land, buildings, and utility systems. In FY 2001, responsibility for BNL waste management activities has been transferred from the DOE Environmental Management Program (EM) to the Nuclear Physics program.

Funding Schedule

	(dollars in thousands)				
	FY 1999	FY 2000	FY 2001	$ Change	% Change
Research					
University Research	17,507	17,426	17,973	+547	+3.1%
National Laboratory Research	36,146	33,595	33,330	-265	-0.8%
Other Research	375[a]	2,826	2,960	+134	+4.7%
Subtotal, Research	54,028	53,847	54,263	+416	+0.8%
Operations					
RHIC Operations	74,870	102,480	108,210	+5,730	+5.6%
National Laboratory Facility	12,557	13,023	13,090	+67	+0.5%
Other Operations	5,450	10,060	10,840	+780	+7.8%
BNL Waste Management	0	0	5,957	+5,957	+100.0%
Subtotal, Operations	92,877	125,563	138,097	+12,534	+10.0%
Total, Heavy Ion Nuclear Physics	146,905	179,410	192,360	+12,950	+7.2%

Detailed Program Justifications

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001

Research

University Research

Support is provided for the research of scientists and students at 33 universities in 21 states.

- Research using relativistic heavy ion beams, involving about two-thirds of the university scientists supported by the Heavy Ion program, is focused on the study of the production and properties of hot, dense nuclear matter at initial experiments at RHIC where an entirely new regime of nuclear matter now becomes available to study for the first time. University researchers are involved in all aspects of the four RHIC detectors; STAR, PHENIX, BRAHMS, and PHOBOS.
- Research using low energy heavy ion beams, involving about a third of the university scientists, is focused on the study of the structure of nuclei with priorities on studies of highly excited nuclear systems, properties of unstable nuclear systems near the limits where protons and neutrons become unbound, and reactions involving unstable nuclei that are of particular importance in nuclear astrophysics. These studies utilize specialized instrumentation at the ANL-ATLAS and

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[a] Excludes $2,100,000 which has been transferred to the SBIR program.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
LBNL-88-inch Cyclotron facilities. Complementary studies are carried out using smaller university facilities (Yale and Texas A&M) whose in-house research programs focus on speciality areas of study and provide an emphasis on student training.	17,507	17,426	17,973

National Laboratory Research

Support is provided for the research programs of scientists at six National Laboratories (ANL, BNL, LBNL, LANL, LLNL and ORNL).

	FY 1999	FY 2000	FY 2001
▪ **BNL RHIC Research:** BNL scientists play a major role in planning and carrying out research with the four detectors (STAR, PHENIX, BRAHMS and PHOBOS) at RHIC and have major responsibilities for maintaining, improving and developing this instrumentation for use by the user community. FY 2001 will be a critical year as all four RHIC detectors reach their full potential for studies of the expected new forms of nuclear matter that will be created in the heavy ion collisions. The priority for the capital equipment included in this funding is on additional experimental equipment for RHIC, (see Major Items of Equipment) primarily for the Electromagnetic Calorimeter enhancement for STAR and for muon instrumentation for PHENIX.	18,055	13,252	11,275
▪ **Other National Laboratory Research:** ANL (ATLAS) and LBNL (88-inch Cyclotron) scientists have major responsibilities for maintaining, improving and developing instrumentation for use by the user communities at their facilities, as well as playing important roles in carrying out research that addresses the program's priorities. Activities will be focused on studies of the properties of nuclei far from stability using specialized instrumentation, studies of nuclear structure with Gammasphere and support of a new Rare Isotope Accelerator (RIA) facility including R&D and preconceptual design. FY 2001 funding of $3,100,000 is provided for RIA activities. Researchers at LANL, LBNL, and ORNL will utilize their laboratory competencies in undertaking the development of and data analysis from RHIC detectors (e.g., STAR and PHENIX) and will play leadership roles in carrying out research utilizing them. The priorities for funding in research will be the RHIC program, and R&D and preconceptual design activities for a proposed Rare Isotope Accelerator (RIA).	18,091	20,343	22,055
Total, National Laboratory Research	36,146	33,595	33,330

	FY 1999	FY 2000	FY 2001
	(dollars in thousands)		

Other Research

	FY 1999	FY 2000	FY 2001
▪ In FY 1999 $2,100,000 was transferred to the SBIR program. Amounts include the estimated requirements for the continuation of the FY 2000 and FY 2001 SBIR and STTR programs and other established obligations.	375	2,826	2,960
Total, Heavy Ion Nuclear Physics Research	54,028	53,847	54,263

Operations

RHIC Operations

- The Relativistic Heavy Ion Collider (RHIC) will initiate data taking operations during FY 2000 and is anticipated to reach nearly full data production capabilities by the end of FY 2001. RHIC is a unique facility whose colliding relativistic heavy ion beams will permit exploration of hot, dense nuclear matter and recreate the transition from quarks to nucleons that characterized the early evolution of the universe. Studies with colliding heavy ion beams will provide researchers with their first laboratory opportunity to explore this new regime of nuclear matter and nuclear interactions that up to now has only been studied theoretically.

	FY 1999	FY 2000	FY 2001
‣ **RHIC Accelerator Operations:** Support is provided for the operation, maintenance, improvement and enhancement of the RHIC accelerator complex. The RHIC complex includes the Tandem, Booster and AGS accelerators that together serve as the injector for RHIC and that individually or in combination have additional capabilities for providing beams for research. In FY 2001 RHIC will operate with a 4800 hour running schedule. About 1600 hours of this schedule is anticipated to be used for beam studies and to commission operations with polarized protons.	66,800	75,170	78,885

RHIC Operations

	(hours of beam)		
	FY 1999	FY 2000	FY 2001
Research	0	1330	3200
Beam Studies	500	2720	1600
Total	500	4050	4800

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
‣ **RHIC Experimental Support:** Support is provided for the operation, maintenance, improvement and enhancement of the RHIC experimental complex, including detectors, experimental halls, computing center and support for users. RHIC detectors (STAR, PHENIX, BRAHMS and PHOBOS) will reach their initial planned potential in FY 2001. Approximately 950 scientists and students from 90 institutions and 19 countries will participate in the research programs of these four detectors.	8,070	27,310	29,325
Total, RHIC Operations	74,870	102,480	108,210

- **National Laboratory Facility Operations**

Support is provided for two National User Facilities: the ATLAS facility at ANL and the 88-inch Cyclotron facility at LBNL for studies of nuclear reactions, structure and fundamental interactions.

- Support is provided for the operation, maintenance, improvement and enhancement of the ATLAS and 88-inch Cyclotron accelerator facilities. FY 2001 operations (and beam hours shown below) reflect emphasis on the complementary Gammasphere program at the 88-inch Cyclotron and the development of radioactive beam capabilities at ATLAS. A vigorous program in search of new elements near the recently discovered elements (Z=116 and 118) will be pursued.

	(hours of beam)		
	FY 1999	FY 2000	FY 2001
Total beam hours (ATLAS/88-inch Cyclotron)	10200	10200	10350

‣ In FY 2001 these low-energy facilities will carry out about 70 experiments conducted by about 400 researchers. Accelerator Improvement Project (AIP) funds and capital equipment are provided for the maintenance and upgrade of these facilities and their research capabilities.	12,557	13,023	13,090

	FY 1999	FY 2000	FY 2001
	(dollars in thousands)		
▪ **Other Operations:** As Landlord for Brookhaven National Laboratory (BNL), the Nuclear Physics program provides GPP funding for minor new construction, other capital alterations and additions, and for buildings and utility systems. Funding of this type is essential for maintaining the productivity and usefulness of Department-owned facilities and in meeting its requirement for safe and reliable facilities operation. Since it is difficult to detail these types of projects in advance, a continuing evaluation of requirements and priorities may result in additions, deletions, and changes in the currently planned projects. The total estimated cost of each project will not exceed $5,000,000. In addition, the program has Landlord responsibility for providing General Purpose Equipment (GPE) at BNL.			
▪ At Brookhaven National Laboratory, modifications to the Booster Synchrotron (part of the RHIC complex) and development of a beam line are underway to provide beams for studies of radiation effects on biological and electronic systems in space. This Booster Applications Facility (BAF) is funded by NASA under a work-for-others agreement at no cost to the Nuclear Physics program.	5,450	10,060	10,840
▪ **BNL Waste Management:** Funding is provided in support of activities related to the packaging, shipment, and disposition of hazardous, radioactive or mixed waste generated in the course of normal operations at Brookhaven National Laboratory.	0	0	5,957
Total, Operations	92,877	125,563	138,097
Total, Heavy Ion Nuclear Physics	146,905	179,410	192,360

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Research	
▪ **University Research**	
‣ FY 2001 funding for University Research provides for a constant level of effort compared to FY 2000 for research and educational activities. Priority in the program will be given to research using RHIC and with exotic nuclei far from stability.	+547
▪ **National Laboratory Research**	
‣ Research funding for RHIC, including capital equipment for detectors, is reduced by about $2,000,000 relative to FY 2000 as several Major Items of Equipment are completed. In FY 2001 there will be an increase of $1,500,000 in funding allocated to R&D and preconceptual design activities for the Rare Isotope Accelerator (RIA) project, bringing the total effort in this subprogram to $3,100,000. (An additional $400,000 for RIA R&D and design activities is provided in the Low Energy subprogram where needed expertise resides.) Other research efforts at the National Laboratories are reduced somewhat and will be focused towards the priority areas of the program.	-265
▪ **Other Research**	
‣ Estimated funding for SBIR and other obligations increase from FY 2000.	+134
Total, Research	+416
Operations	
▪ **RHIC Operations**	
‣ FY 2001 funding provides for an estimated 4800 hours running schedule (3200 hours for research), compared to 4050 hours (1330 hours for research) in FY 2000. Capital Equipment and AIP funding are provided at levels approaching what was recommended as appropriate in the RHIC Operations Review carried out by NSAC.	+5,730
▪ **National Laboratory Facility Operations**	
‣ In FY 2001, funding for operations of ATLAS and the 88-Inch Cyclotron is increased by about 4% compared with FY 2000, resulting in an increase in beam hours. Capital Equipment and AIP funding are decreased by approximately the same percentage.	+67
▪ **Other Operations**	
‣ FY 2001 GPP for Brookhaven National Laboratory is increased to support projects that will enhance the usefulness of aging facilities.	+780

	FY 2001 vs. FY 2000 ($000)
▪ **BNL Waste Management**	
‣ As part of the landlord responsibilities for Brookhaven National Laboratory the program assumes responsibility for the waste treatment program previously budgeted for by Environmental Management	+5,957
Total, Operations	+12,534
Total Funding Change, Heavy Ion Nuclear Physics	+12,950

Low Energy Nuclear Physics

Mission Supporting Goals and Objectives

The Low Energy Nuclear Physics subprogram supports research directed at understanding the structure of nuclei, nuclear reaction mechanisms, and experimental tests of fundamental symmetries. At the present time, emphasis is placed on addressing issues in nuclear astrophysics. This research is generally conducted using beams provided by accelerator facilities operated by this subprogram, other Department of Energy programs, or at other domestic or foreign facilities. The Low Energy Nuclear Physics subprogram supports the operation of the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory. University-based research is an important feature of the Low Energy subprogram. Since most of the required facilities are relatively small, they are appropriate for siting on university campuses, where they provide unique opportunities for hands-on training of nuclear experimentalists who are so important to the future of this field. Many of these scientists, after obtaining their Ph.D.s, contribute to a wide variety of nuclear technology programs of interest to the DOE. Part of this work can often be accomplished without the use of accelerators. The study of neutrinos from the sun, whose rate of production is not understood, is an example. Included in this subprogram are the activities that are aimed at providing information services on critical nuclear data and have as a goal the compilation and dissemination of an accurate and complete nuclear data information base that is readily accessible and user oriented. In FY 2001, funding will be provided for an expanded program of R&D and preconceptual design activities in support of an advanced Rare Isotope Accelerator (RIA) facility (partially funded in Heavy Ion Nuclear Physics subprogram).

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
University Research	9,895	9,727	10,475	+748	+7.7%
National Laboratory Research	8,038	9,086	8,360	-726	-8.0%
Nuclear Data	4,775	4,880	5,050	+170	+3.5%
Other	290[a]	1,145	965	-180	-15.7%
RIB Operations	9,310	8,941	9,120	+179	+2.0%
Total, Low Energy Nuclear Physics	32,308	33,779	33,970	+191	+0.6%

[a] Excludes $810,000 which has been transferred to the SBIR program.

Detailed Program Justifications

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
University Research			
▪ The three main components of research at universities in this subprogram are nuclear astrophysics, fundamental interactions in nuclei, and the structure of nuclei.			
▪ Two university accelerators are supported in Low Energy: the University of Washington, Nuclear Physics Laboratory (NPL), and the Triangle Universities Nuclear Laboratory (TUNL) facility at Duke University. These small university facilities fit within the low energy program by providing a source of light ion beams. Long term measurements of a detailed nature are possible at these dedicated facilities and they are used to make measurements that address questions of a fundamental physics nature.			
▪ University scientists perform research at on-site facilities, as user groups at National Laboratory facilities, and at the Sudbury Neutrino Observatory (SNO). These activities address a broad range of fundamental issues as diverse as properties of nuclei, the nature of the weak-interaction and the production mechanisms of chemical elements in stars and supernovae..	9,895	9,727	10,475
National Laboratory Research			
▪ **Radioactive Ion Beam Facility Research:**			
‣ The RIB facility focuses mainly on nuclear astrophysics problems bearing on the creation of the elements and on the properties of nuclei with extreme proton/neutron ratios.			
‣ The Daresbury Recoil Separator, a $2,000,000 device contributed by the United Kingdom, is being utilized to separate the products of interest from particle backgrounds that are a trillion times more intense, enabling the measurement of the important nuclear reactions that fuel the explosion of stars.			
‣ Capital equipment funds are provided to develop new beam species and for research instrumentation.			
‣ Research and Development (R&D) activities leading to an advanced Rare Isotope Accelerator (RIA) will continue	4,808	4,254	4,985

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
▪ **Other National Laboratory Research:**			
‣ In a major effort to study the processes that control our sun, the Sudbury Neutrino Observatory (SNO) was created. This observatory consists of a 40 foot diameter plastic (acrylic) vessel holding 1,000 tons of heavy water that is the solar neutrino detector. SNO is located 6,800 feet underground. The detector water fill was completed in FY 1999 and data taking has started. The level of SNO support at the national laboratories is at a level of effort that allows for efficient collection and analysis of data.			
‣ The SNO detector, whose first results are expected in FY 2001, addresses the question of whether the observed dearth of solar neutrinos results from unexpected properties of the sun, or whether it results from a fundamental property of neutrinos-namely that neutrinos produced in radioactive decay in the sun change their nature during the time it takes them to reach the earth. This latter explanation would imply that the neutrinos have mass.			
‣ Funds are also provided for R&D and preconceptual design activities directed at the development of an advanced Rare Isotope Accelerator (RIA).	3,230	4,832	3,375
Total, National Laboratory Research	8,038	9,086	8,360

Nuclear Data

- This is a service function of the Nuclear Physics program that collects, evaluates, stores, and disseminates information on nuclear properties and reaction processes for the community and the nation. The focal point for its national and international activities is at the DOE managed National Nuclear Data Center (NNDC) at Brookhaven National Laboratory.
- The NNDC relies on a network of individual nuclear data professionals located in universities and at other national laboratories who assist in assessing data as well as developing new novel, user friendly electronic network capabilities.
- The U.S. Nuclear Data Network (USNDN), a collaboration of DOE supported nuclear data

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
scientists, reports to and supports the NNDC in data evaluation and development of on-line access capabilities	4,775	4,880	5,050

Other

‣ In FY 1999 $810,000 was transferred to the SBIR program. The FY 2000 and FY 2001 amounts include the estimated requirement for the continuation of the FY 2000 and FY 2001 SBIR and STTR programs and other established obligations. The Lawrence and Fermi Awards that are funded under this line, provide annual monetary awards to honorees selected by the Department of Energy for their outstanding contributions to nuclear science.	290	1,145	965

RIB Operations

- The RIB facility is planned to provide beam hours for research as indicated below:

	(hours of beam)		
	FY 1999	FY 2000	FY 2001
RIB	2400	2400	2300

‣ The RIB facility is a technically difficult project, that couples the existing cyclotron and tandem accelerators. Becoming fully operational in FY 1998, it is now routinely providing radioactive ion beams of arsenic, fluorine and Nickel-56 for a user community of over 200 researchers.

‣ Research at the Oak Ridge Electron Linear Accelerator (ORELA), that is also operated by RIB staff, is aimed at resolving discrepancies in the rate of production of primordial elements compared with theoretical predictions, such as models that predict the formation of heavy elements like carbon, nitrogen, and oxygen in the Big Bang.	9,310	8,941	9,120
Total, Low Energy Nuclear Physics	32,308	33,779	33,970

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
▪ **University Research**	
‣ FY 2001 funding provides constant effort support for research, and additional capital equipment support for new initiatives in neutrino related research, such as the KamLAND experiment, and nuclear astrophysics related projects.	+748
▪ **National Laboratory Research**	
‣ Research support is reduced compared to FY 2000 with high priority on nuclear astrophysics studies and involvement in the KamLAND experiment. Support at the level of $400,000 continues for R&D and preconceptual design activities for a next generation Rare Isotope Accelerator (RIA). Capital equipment investments for activities in National Laboratory Research are reduced due to completion of SNO related projects.	-726
▪ **Nuclear Data**	
‣ Funding provides a limited increase in operating costs for the nuclear data facilities and a new initiative in nuclear astrophysics data services.	+170
▪ **Other**	
‣ Estimated FY 2001 funds for SBIR decrease compared to FY 2000.........................	-180
▪ **RIB Operations**	
‣ Operations are funded at slightly less than a constant effort than in FY 2000.	+179
Total Funding Change, Low Energy Nuclear Physics	+191

Nuclear Theory

Mission Supporting Goals and Objectives

Theoretical Nuclear Physics is a program of fundamental scientific research that provides new insight into the observed behavior of atomic nuclei. From continuing interactions with experimentalists and experimental data, solvable mathematical models are developed which describe observed nuclear properties, and the predictions of the models are tested with further experiments. From this process evolves a deeper understanding of the nucleus. Traditionally, there are two generic types of nuclear models: (1) microscopic models where the nucleus is viewed as a system of interacting discrete protons and neutrons, and (2) collective models where the nucleus is treated as a drop of fluid. With the establishment of the Quantum Chromodynamics and the standard model, the ultimate goal of nuclear theory now is to understand nuclear models, and hence nuclei, in terms of quarks and gluons. An area of increasing interest recently is in nuclear astrophysics-topics such as supernova explosions, nucleosynthesis of the elements, and the properties of neutrinos from the sun.

The Nuclear Theory program supports all areas of nuclear physics, and is carried out at universities and National Laboratories. Some of the investigations depend crucially on access to forefront computing, and to the development of efficient algorithms to use these forefront devices. Components of the program are selected primarily on the basis of peer review by internationally recognized experts. A very significant component of the program is the Institute for Nuclear Theory (INT), where there is an ongoing series of special topic programs and workshops which include experimentalists. The Institute is a seedbed for new collaborations, ideas, and directions in nuclear physics.

The program is greatly enhanced through interactions with complementary programs overseas and those supported by the National Science Foundation. Many foreign theorists participate on advisory groups and as peer reviewers. There is large participation in the INT by researchers from Europe and Japan.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
University Research	10,363	10,113	10,535	+422	+4.2%
National Laboratory Research	5,277	5,562	7,620	+2,058	+37.0%
Total, Nuclear Theory	15,640	15,675	18,155	+2,480	+15.8%

Detailed Program Justifications

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
University Research			
▪ Research is conducted through individual grants to researchers at roughly 40 universities.			
▪ The range of topics studied through these grants is broad, and each of the active areas of experimental nuclear physics is supported by nuclear theory activities.			
▪ The overall character of the research program evolves with time to reflect changes in the overall nuclear physics program through redirecting some individual programs, phasing out other programs and starting new programs.			
▪ Almost 100 Ph.D. students are supported by the Theory program; a major source of new Ph.D.s in nuclear physics in this country.			
▪ The level of effort in this activity has been essentially constant in recent years. The bulk of the funds provided are used for salary support for faculty, postdocs, and students doing thesis research. Thus, a constant level of effort depends on a cost-of-living increase.			
▪ The number of nuclear theorists supported in this activity is consistent with the recommendations for manpower levels in the report of the DOE/NSF Nuclear Science Advisory Committee Subcommittee on Nuclear Theory-1988.	10,363	10,113	10,535
National Laboratory Research			
▪ Funding provides for new activities to model and calculate complex astrophysical nuclear processes, for example, in stellar supernovae explosions, and the quark/gluon-based structure of nuclei using “lattice gauge” techniques. Both efforts require investments in new computational modeling and simulation research and show great promise in pushing our understanding of the physics of these processes to new levels.			
▪ Through this activity, theoretical nuclear physics groups are supported at 6 National Laboratories.			
▪ The range of topics in these programs is broad, and each of the active areas of experimental nuclear physics is supported by at least some of these nuclear theory activities.			

	FY 1999	FY 2000	FY 2001
▪ In all cases, the nuclear theory research at a given laboratory provides support to the experimental programs at the laboratory, or takes advantage of some unique facilities/programs at that laboratory.			
▪ The larger size and diversity of the National Laboratory groups make them particularly good sites for the training of nuclear theory postdocs.			
▪ The level of effort in this activity has been essentially constant in recent years. The bulk of the funds provided are used for salary support for staff. Thus, a constant level of effort depends on a cost-of-living increase.			
▪ The number of nuclear theorists supported in this activity is consistent with the recommendations for manpower levels in the report of the DOE/NSF Nuclear Science Advisory Committee Subcommittee on Nuclear Theory-1988.	5,277	5,562	7,620
Total, Nuclear Theory	15,640	15,675	18,155

(dollars in thousands)

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
▪ **University Research**	
‣ Funding level reflects an increased level of support for the university grants program.	+422
▪ **National Laboratory Research**	
‣ Funding provides for new efforts which require investments in computational modeling and simulation activities which show great promise for pushing our understanding of the physics to new levels. These activities will model and calculate complex astrophysical nuclear processes, for example, in stellar supernovae explosions, and the quark/gluon based structure of nuclei using "lattice gauge" techniques.	+2,058
Total Funding Change, Nuclear Theory	+2,480

Capital Operating Expense and Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
General Plant Projects	4,000	5,855	6,735	+880	+15.0%
Accelerator Improvement Projects	5,520	4,400	5,500	+1,100	+25.0%
Capital Equipment..................................	30,070	30,880	34,155	+3,275	+10.6%
Total, Capital Operating Expenses	39,590	41,135	46,390	+5,255	+12.8%

Major Items of Equipment *(TEC $2 million or greater)*

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp-riations	FY 1999	FY 2000	FY 2001	Accept-ance Date
STAR Silicon Vertex Tracker	7,000	4,950	1,300	750	0	FY 2000
PHENIX Muon Arm Instrumentation	12,900	5,975	2,635	2,525	800	FY 2002
Analysis System for RHIC Detectors	7,900	2,775	3,600	1,525	0	FY 2000
BLAST Large Acceptance Detector	5,200	900	1,600	1,500	1,200	FY 2001
STAR EM Calorimeter	8,600	0	0	1,800	2,800	TBD
G0 Experiment Detector [a]	3,387	400	1,064	1,004	874	FY 2002
Total, Major Items of Equipment		15,000	10,199	9,104	5,674	

[a] The G0 Experiment Detector at TJNAF began as an NSF project with a small contribution of DOE funds (below MIE threshold). Subsequently, the cost estimate for the detector increased, leading to increased DOE and NSF contributions. The DOE contribution was raised above the MIE threshold. Therefore a MIE has been identified in the FY 2001 budget. The NSF contribution to this effort in actual year dollars is $3,605,000.